SPECIFICATIONS

AIRPORT TRAFFIC CONTROL TOWER
FACILITY MAJOR IMPROVEMENTS

FAA-FLL-1508912

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Fort Lauderdale International Airport
Fort Lauderdale, Florida

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ISSUE FOR CONSTRUCTION

08/05/2020

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TABLE OF CONTENTS

DIVISION 01 - GENERAL CONDITIONS (VOLUME 1 OF 2)
01 00 00 GENERAL PARAGRAPHS
01 10 00 SUMMARY OF WORK
01 10 12 CONSTRUCTION ADMINISTRATION FORMS
01 10 15 ACRONYMS AND DEFINITIONS
01 25 00 SUBSTITUTION PROCEDURES
01 31 00 PROJECT MANAGEMENT AND COORDINATION
01 32 00 CONTRACTOR-PREPARED NETWORK ANALYSIS SYSTEM
01 32 00.20 CONTRACTOR-PREPARED CONSTRUCTION SCHEDULE
01 33 00 SUBMITTAL PROCEDURES
01 40 00 CONTRACTOR QUALITY CONTROL
01 50 00 TEMPORARY FACILITIES AND CONTROLS
01 52 16 SAFETY REQUIREMENTS
01 56 23 BARRIERS AND ENCLOSURES
01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS
01 58 13 POSTING OF NOTICES
01 71 33 PROTECTION OF WORK AND PROPERTY
01 74 13 CONSTRUCTION CLEANING
01 77 00 CLOSEOUT PROCEDURES FOR SUSTAINABLE DESIGN
01 77 10 FINAL CLEANING
01 78 23 OPERATION AND MAINTENANCE DATA
01 78 36 WARRANTIES AND GUARANTEES
01 78 39 PROJECT RECORD DOCUMENTS
01 81 09 TESTING AIR QUALITY

DIVISION 02 - EXISTING CONDITIONS
02 01 00 INTERIM LIFE SAFETY MEASURES FOR FACILITIES UNDER CONSTRUCTION
02 03 00 GENERAL REQUIREMENTS FOR DEMOLTION AND RENOVATION
02 82 15 THIRD PARTY AIR MONITORING FOR ASBESTOS CONTAINING MATERIALS
02 82 33 REMOVAL AND DISPOSAL OF ASBESTOS CONTAINING MATERIALS

DIVISION 03 – CONCRETE
03 01 00 REHABILITATION OF CONCRETE

DIVISION 07 - THERMAL AND MOISTURE PROTECTION
07 21 00 THERMAL INSULATION
07 42 13 METAL WALL PANELS
07 54 19 POLYVINYL CHLORIDE (PVC) MEMBRANE ROOFING
07 57 00 WATERPROOF DECK COATING
07 62 00 SHEET METAL FLASHING AND TRIM
07 71 00 ROOF SPECIALTIES
07 72 00 ROOF ACCESSORIES
07 72 33 ROOF HATCHES
07 84 00 FIRESTOPPING
07 84 13 PENETRATION FIRESTOPPING
07 92 00 JOINT SEALANTS

07 95 00 EXPANSION CONTROL

DIVISION 08 - OPENINGS

08 11 13 HOLLOW METAL DOORS AND FRAMES
08 14 16 FLUSH WOOD DOORS
08 31 13 ACCESS DOORS AND FRAMES
08 41 13 ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
08 71 00 DOOR HARDWARE
08 83 00 MIRRORS

DIVISION 09 - FINISHES

09 22 16 NON-STRUCTURAL METAL FRAMING
09 29 00 GYPSUM BOARD
09 30 00 TILING
09 51 13 ACOUSTICAL PANEL CEILINGS
09 65 13 RESILIENT BASE AND ACCESSORIES
09 65 19 RESILIENT TILE FLOORING
09 68 13 TILE CARPETING
09 68 13.10 CONDUCTIVE TILE CARPETING
09 91 00 PAINTING
09 96 46 INTUMESCENT PAINT

DIVISION 10 – SPECIALTIES

10 21 13 TOILET COMPARTMENTS
10 28 00 TOILET, BATH AND LAUNDRY ACCESSORIES

DIVISION 12 - FURNISHINGS

12 36 61.16 SOLID SURFACING COUNTERTOPS

DIVISION 21 – FIRE SUPPRESION

21 12 00 STANDPIPE SYSTEMS

DIVISION 22 – PLUMBING

22 05 00 COMMON WORK RESULTS FOR PLUMBING
22 05 17 SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
22 05 18 ESCUTCHEONS FOR PLUMBING PIPING
22 05 23.12 BALL VALVES FOR PLUMBING PIPING
22 05 53 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
22 07 19 PLUMBING PIPING INSULATION
22 11 16 DOMESTIC WATER PIPING
22 11 19 DOMESTIC WATER PIPING SPECIALTIES
22 13 16 SANITARY WASTE AND VENT PIPING
22 13 19 SANITARY WASTE PIPING SPECIALTIES
22 13 19.13 SANITARY DRAINS
22 14 23 STORM DRAINAGE PIPING SPECIALTIES
22 42 13.13 COMMERCIAL WATER CLOSETS
22 42 13.16 COMMERCIAL URINALS.

22 42 16.13 COMMERCIAL LAVATORIES

DIVISION 23 - HEATING VENTILATING AND AIR CONDITIONING

23 05 00 COMMON WORK RESULTS FOR HVAC
23 05 13 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
23 05 53 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
23 05 93 TESTING, ADJUSTING, AND BALANCING
23 07 00 HVAC INSULATION
23 08 20 HVAC COMMISSIONING-GENERAL
23 09 23 CONTROLS FOR HVAC
23 31 13 METAL DUCTS
23 33 00 AIR DUCT ACCESSORIES
23 34 23 POWER VENTILATORS
23 36 00 AIR TERMINAL UNITS
23 62 00 PACKAGED COMPRESSOR AND CONDENSER UNITS
23 82 19 FAN COIL UNITS

DIVISION 26 – ELECTRICAL (VOLUME 2 OF 2)

26 05 00 COMMON WORK RESULTS FOR ELECTRICAL
26 05 19 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
26 05 33 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
26 05 48 VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS
26 05 53 IDENTIFICATION FOR ELECTRICAL SYSTEMS
26 27 26 WIRING DEVICES
26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
26 29 13 ENCLOSED CONTROLLERS
26 29 23 VARIABLE-FREQUENCY MOTOR CONTROLLERS
26 41 13 LIGHTNING PROTECTION FOR STRUCTURES
26 51 19 INTERIOR LIGHTING
26 56 00 EXTERIOR LIGHTING
26 52 19 EMERGENCY AND EXIT LIGHTING

DIVISION 33 - UTILITIES

33 25 30 SANITARY SEWERS

APPENDICES:

APPENDIX 1
US DOT/FAA Specification FAA-STD-019f Lightning and Surge Protection, Grounding, Bonding, and Shielding Requirements for Facilities and Electronic Equipment

APPENDIX 2
FEMA 412 Seismic Restraints for Mechanical Equipment

APPENDIX 3
FEMA 413 Seismic Restraints for Electrical Equipment

APPENDIX 4
FEMA 414 Seismic Restraints for Duct and Pipe

APPENDIX 5
Asbestos Report

SECTION 01 00 00- GENERAL PARAGRAPHS

PART 1 - GENERAL

1.1 PRE BID SITE VISIT

A. The offerer are encouraged and expected to carefully examine the areas of the proposed work, but not required, to see first-hand the extent of the work involved. The submission of a proposal will be considered prima facie evidence that the offerer has made such examination and is satisfied as to the conditions to be encountered in performing the work. It is the obligation of the offerer to make their own interpretation of the site subsurface data included in the appendix as to the nature and extent of the work, including materials to be excavated. For access to the site, contact the Contracting Officer indicated in the solicitation.

1.2 TIME FOR COMPLETION

A. The work shall be completed within the time period defined in the General Contract.

1.3 LIQUIDATED DAMAGES

A. Contractor and his sureties shall be liable for any damages to the Government resulting from his refusal or failure to complete the work within the time fixed in the contract or any extensions thereof, pursuant to the clause of this contract entitled, "AMS Clause 3.10.6-6, Default (Fixed price Construction)."

1.4 DRAWINGS, SPECIFICATIONS, AND OTHER CONTRACT DOCUMENTS

A. The requirements of AMS Clause 3.2.2.3-33, Order of precedence and AMS Clause 3.2.2.3-60, Specifications, Drawings, and Material Submittals shall apply.

B. Drawings showing general outlines and details necessary for a comprehensive understanding of the work form a part of the Contract Documents. The total number and the titles of the drawings constituting the Drawings are given in the index of the Drawings. All work under the Contract shall be performed in all respects in compliance with the requirements of the Contract Documents.

C. The Contract Documents provide for a complete work, and may have been prepared in divisions of various crafts, trades and other categories of work. The Contractor is responsible for the performance of all work under the Contract regardless of any such divisions, and shall ensure that all of the work is performed and completed.

D. The FAA will provide the Contractor with one bound copy of the construction drawings and specifications for the Contractor's use during the execution of the Contract. The Contractor may reproduce these documents for its use during the performance of the work under this Contract.

E. The Contractor shall maintain at the Site at all times at least one (1) copy of Drawings, Specifications and all other Contract Documents, together with at least one (1) complete set of approved Shop Drawings and approved samples.

F. The Contractor shall make available at the job site one copy of each referenced standard (or as directed by the COR, for the Contractor's and the FAA's use during the time that work is covered by the standard.

G. The Contract, Drawings, Specifications, and all referenced standards cited are essential parts of the Contract requirements. A requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work.

H. The Contractor shall not take advantage of any apparent error, omission, discrepancy, or ambiguity on the Drawings or Specifications. If any error, omission, discrepancy, or ambiguity is found by the Contractor in the Drawings or Specifications, the Contractor shall refer the same to the Contracting Officer (CO) prior to beginning work on affected task(s), for interpretation and decision, and such decision shall be final.

I. The CO shall have the right to correct apparent errors or omissions in the Drawings and Specifications and to make such interpretations as he may deem necessary for the proper fulfillment of the Contract Documents. During the course of the work, should any conflicts, ambiguities, or discrepancies be found that are not addressed or any discrepancies between the Drawings and the Specifications to which the Contractor has failed to call attention before submitting the offer, then the CO will interpret the intent of the Drawings and Specifications and the Contractor hereby agrees to abide by the CO's interpretation and agrees to carry out the work in accordance with the decision of the CO. In such event the Contractor will be held to have included in the offer the most expensive material and/or method of construction.

J. When a material, article, or equipment is designated by a brand name, and more than one brand name is listed, it will be understood that the design is based on one of the brand name listed products. The contractor will be responsible for all coordination necessary to accommodate the material, article, or equipment actually being provided without additional cost to the government.

K. The organization of the contract Documents into divisions, sections and articles, and the arrangement of Drawings does not restrict or limit the Contractor in dividing the Work among Subcontractors or in establishing the extent of work to be performed by any trade.

L. Product and Reference Standards:

1. When descriptive catalog designations including manufacturer's name, product brand

name, or model number are referred to in the Contract Documents, such designations shall be considered as being those found in industry publications of current issue on the date of the first advertisement for offers.

2. When standards of the Federal Government, State Department of Transportation, Standards Organization such as ASTM, AASHTO, AWS, or ANSI, trade societies, or trade associations are referred in the Contract Documents by specific date of issue, these shall be considered a part of this Contract. When such references do not bear a date of issue, the current published edition on the date of the first advertisement for offers shall be considered as part of the Contract.
3. Where in the Contract Documents an item is identified by a particular manufacturer’s name, model or other code it shall be interpreted to include other manufacturers’ product of like and equal quality whether the words “or equal” are included or not.
4. Wherever a particular manufacturer’s product is required, to the exclusion of all others, appropriate language is included in the Contract Documents.
5. Wherever the terms, “as directed”, “ordered”, “permitted”, “designate”, “as approved”, “approved equal”, “or equal”, “acceptable” and other words of similar meaning which authorize an exercise of judgement are used in the Contract Documents, such judgment shall be vested only in the Architect/Engineer and/or the FAA.

1.5 CONFORMITY WITH DRAWINGS AND SPECIFICATIONS

A. No deviation from the Drawings, Specifications and other Contract Documents shall be permitted without the prior written approval of the Contracting Officer.

1.6 SUPERVISION AND CONSTRUCTION PROCEDURES

A. At all times during performance of this contract, and until the work is completed and accepted, the Contractor shall directly superintend the work or assign and have on the worksite a competent superintendent who is satisfactory to the CO and has the authority to act for the Contractor.

B. The Contractor shall supervise and direct the Work, using the Contractor's best skill and attention. The Contractor shall be solely responsible for and have control over construction means, methods, techniques, sequences, and procedures and for coordinating all portions of the Work under the Contract including coordination of the duties of all trades, unless the Contract Documents give other specific instructions concerning these matters.

C. The Contractor shall control its operations and those of its Subcontractors and Suppliers to assure the least inconvenience to the traveling public. Under all circumstances, safety shall be the most important consideration.

D. Contractor shall lay out all work well enough in advance to avoid conflicts or interferences with other work in progress so that in case of interference the layout may be altered to suit the conditions, prior to the installation of any work and without additional cost to the FAA. The contractor shall be responsible to coordinate all work and take all action as required to avoid conflicts between trades. Unless specifically noted otherwise, establish the exact location of equipment based on the actual dimensions of equipment furnished. Mechanical and electrical work shall be coordinated so that work may proceed according to the following sequence to avoid conflict:

1. Air handling unit placement
2. Gravity Pipes (drains, sewer, storm)
3. Duct routing
4. Cable tray placement
5. Light fixture location
6. Pressure pipe routing
7. Conduit routing

1.7 CORRESPONDENCE

A. Contract correspondence shall be directed to the CO with a copy to the COR. Submittals will be sent direct to the COR with a copy of the transmittal letter to the CO.

1.8 LIST OF SUBCONTRACTORS

A. The Contractor shall, within 10 calendar days after award, furnish to the CO with a copy to the COR, a list of subcontractors showing the type of work each will perform. If all subcontracts have not been awarded when the initial list is submitted, the Contractor shall update the list.

1.9 PRECONSTRUCTION CONFERENCE

A. The CO will arrange a conference at a location, mutually agreeable to the CO and the Contractor as soon as practicable after award of a contract. It will be mandatory that the Contractor or his designated representative attends.

1.10 WORK NOT INCLUDED

A. Items noted on the drawings, details, or schedules as "N.I.C.” (Not in Contract) are not included in this contract.

1.11 REQUIRED INSURANCE

A. Insurance Requirements

Insurance Requirements shall meet the AMS Insurance clause unless noted otherwise in the Contract.

1.12 SECURITY REQUIREMENTS

A. Personnel List: Contractor shall provide the Contracting Officer Representative with a list of Contractor's personnel who will require access to the site. The list shall be kept current during project work. The Contractor shall provide all personnel with readily identifiable numbered badges during the period their access to the site is required. Badges shall be worn on outer clothes at all times when at work in the site.

B. Security Investigation: Contractor's site superintendent shall submit to an FAA security background check and obtain an official FAA contractor ID badge. Other Contractor personnel may be subject to security investigation by FAA. Upon request by the Contracting Officer Representative, the Contractor shall promptly complete all security forms provided by the Contracting Officer Representative.

1.13 CHANGED CONDITIONS

A. Wherever changed conditions as defined in Contract Clause entitled, "Changes and Changed Conditions" are encountered, and wherever conditions exposed during the course of the work necessitate a change from quantities indicated or specified as either estimated quantities or as a basis for offers, whether or not provision for a change in price for such variation is specified, the CO must be notified in writing and written directions to do so must be obtained before quantities stated in the contract documents are exceeded.

1.14 EXISTING WORK

A. The disassembling, disconnecting, cutting, removal, or altering in any way of existing work shall be carried on in such a manner as to prevent injury or damage to all portions of existing work, whether they are to remain in place, be re-used in the new work, or be salvaged and stored.

B. All portions of existing work which have been cut, damaged, or altered in any way during construction operations shall be repaired or replaced in kind in an approved manner to match existing or adjoining work. All work of this nature shall be performed by the Contractor at his expense and shall be as directed. Existing work shall, at the completion of all operations, be left in a condition as good as existed before the new work started.

1.15 MATERIALS AND EQUIPMENT TO BE SALVAGED

A. Except where specifically specified otherwise herein, or designated on the drawings, all existing materials and equipment which are required to be removed or disconnected to perform the work but are not indicated or specified for use in the new work, shall become the property of the Contractor and shall be disposed of properly. The Government may elect to salvage any or all materials removed by the Contractor by giving prior notice and pricing up materials at job site.

1.16 PAYMENTS TO CONTRACTOR

A. The obligation of the Government to make any of the payments required under any of the provisions of this contract shall, in the discretion of the CO be subject to 1) reasonable deductions on account of defects in material or workmanship, and 2) any claims which the Government may have against the Contractor under or in connection with this contract. Any overpayments to the Contractor shall, unless otherwise adjusted, be repaid to the Government upon demand.

1.17 PARTIAL OCCUPANCY OR USE

A. The FAA may occupy or use any completed or partially completed portion of the Work at any stage and, if the FAA chooses such partial occupancy, the Contractor and FAA shall designate by an agreement the conditions of such partial occupancy. Such partial occupancy or use may commence whether or not the portion is substantially complete, provided the FAA and Contractor have accepted in writing the responsibilities assigned to each of them by the COR for payments, retainage if any, security, maintenance, heat, utilities, damage to the Work and insurance, and have agreed in writing concerning the period for correction of the Work and commencement of warranties required by the Contract Documents. Consent of the Contractor to partial occupancy or use by the FAA shall not be unreasonably withheld.

1.18 UNCOVERING AND CORRECTION OF WORK

A. Uncovering Work

1. If any portion of the Work is covered contrary to the RE's request or to requirements specifically expressed in the Contract Documents, it must, if required in writing by the COR be uncovered for his observation and be recovered (if corrections are not required) or be corrected, if applicable, at the Contractor's expense without change in the Contract Time.
2. If a portion of the Work has been covered which the COR or any applicable governmental authority has not specifically requested to observe prior to its being covered, the COR may request to see such Work and it shall be uncovered by the Contractor. If such work is in accordance with the Contract Documents, costs of uncovering and restoration shall, by appropriate Change Order, be charged to the FAA. If such Work is not in accordance with the Contract Documents, the Contractor shall pay such costs unless the condition was caused by the FAA or a separate contractor in which event the FAA shall be responsible for payment of such costs.

B. Correction Of Work

1. The Contractor shall promptly correct Work rejected by the COR or any governmental authority that fails to conform to the requirements of the Contract Documents, whether observed before or after Substantial Completion and whether or not fabricated, installed or completed. The Contractor shall bear all costs of correcting such rejected Work, including additional testing and inspections and compensation for the RE's services and

expenses incurred by the FAA.

2. If, within two years after the date of Substantial Completion of the Work or designated portion thereof, or after the date for commencement of warranties established above, or by terms of an applicable special warranty required by the Contract Documents, any of the work is found to be not in accordance with the requirements of the Contract Documents, the Contractor shall correct it promptly after receipt of written notice from the FAA to do so unless the FAA has previously given the Contractor a written acceptance of that specific condition. This period of two years shall be extended with respect to portions of Work first performed after Substantial Completion by the period of time between Substantial Completion and the actual performance of the Work. This obligation shall survive acceptance of the Work under the Contract and termination of the Contract. The FAA shall give such notice within a reasonable amount of time after discovery of the condition.
3. The Contractor shall remove from the site portions of the Work that are not in accordance with the requirements of the Contract Documents and are neither corrected by the Contractor nor accepted by the FAA.
4. If the Contractor fails to correct nonconforming Work within a reasonable time, the FAA may correct it in accordance with General Provisions. If the Contractor does not proceed with correction of such nonconforming Work within a reasonable time fixed by written notice from the RE, the FAA may correct or remove such nonconforming work and all costs for such corrections or removals shall be assessed against the Contractor.
5. The Contractor shall bear the cost of correcting destroyed or damaged Work, whether completed or partially completed, of the FAA or separate contractors caused by the Contractor's performing correction or removal of Work which is not in accordance with the requirements of the Contract Documents.
6. Nothing contained herein shall be construed to establish a period of limitation with respect to other obligations that the Contractor might have under the Contract Documents. Establishment of the time period of two years as described above relates only to the specific obligation of the Contractor to correct the Work, and has no relationship to the time within which the obligation to comply with the Contract Documents may be sought to be enforced, nor to the time within which proceedings may be commenced to establish the Contractor's liability and damages with respect to the Contractor's obligations other than specifically to correct the Work.

C. Acceptance Of Nonconforming Work

1. If the FAA prefers to accept Work that is not in accordance with the requirements of the Contract Documents, the FAA may do so instead of requiring its removal or correction. If the FAA accepts the Work under such circumstances, the Total Contract Price will be reduced in an equitable manner as determined by the Contracting Officer, whether or not final payment has been made.

D. Terms and Conditions” and “Contract Clauses”

1. Wherever a reference to a clause of the General Provisions or General Conditions occurs in a section of the specifications, it shall be taken to mean the “Terms and Conditions” and “Contract Clauses” having the same title as the referenced General Provisions or General Conditions clause.

1.19 UNDERGROUND UTILITIES

A. Utilities Encountered - Efforts have been taken to locate all the underground utilities and cables on the contract drawings; however, unforeseen utilities and underground cables may be encountered. Actual cable locations shall be verified in the field by the Contractor by hand digging a minimum of five (5') on each side of the cable. FAA owned cable will be marked by the FAA prior to the start of work by the Contractor.

1.20 LOCATION OF SERVICES

A. The FAA does not guarantee the accuracy or the completeness of the location information relating to existing utility services, facilities, or structures that may be shown on the drawings. Any inaccuracy or omission in such information shall not relieve Contractor of its responsibility to protect such existing features from damage or unscheduled interruption of service.

1.21 COOPERATE WITH OTHER ENTITIES

A. Cooperate with the FAA, the Airport Authority, and other public or private utility services, or a utility service of another government agency that may be authorized by the FAA to construct, reconstruct, or maintain such utility services or facilities during the progress of the work. Control operations to prevent the unscheduled interruption of such utility services and facilities.

1.22 NOTICE TO FAA/OPERATORS

A. Prior to commencing the work in the general vicinity of an existing utility service or facility, Contractor shall notify each FAA/operator in writing of activities that might affect its interests. If, in Contractor's opinion, the FAA/operator's assistance is needed to locate the utility service or facility or the presence of a representative of the FAA/operator is desirable to observe the work, such advice should be included in the notification. Furnish a copy of such written notices to RE.

1.23 EXCAVATION METHODS

A. Where the outside limits of an underground utility service have been located and staked on the ground, Contractor shall use excavation methods acceptable to the COR as may be required to insure protection from damage due to Contractor's operations.

1.24 DAMAGE TO SERVICES

A. Should Contractor damage or interrupt the operation of a utility service or facility by accident or otherwise, it shall immediately notify in writing the FAA/operator, appropriate public safety authorities, and the COR and shall take all reasonable measures to prevent further damage or interruption of service. Cooperate with the utility service or facility FAA and the COR continuously until such damage has been repaired and service restored.

1.25 FAILURE TO PROTECT PROPERTY

A. Contractor shall not be entitled to any extension of time or compensation on account of Contractor’s failure to protect all facilities, equipment, materials and other property as described herein. All costs in connection with any Improvements or restoration necessary or required by reason of unauthorized obstruction, damage, or use shall be borne by Contractor.

1.26 UTILITY CONTRACTOR LICENSING REQUIREMENTS

A. Contractor shall comply with all state and local requirements for construction of utilities.

1.27 ASBESTOS AND LEAD FREE CERTIFICATION

A. FAA policy is to construct all new facilities without asbestos or lead containing products. The Contractor shall provide a letter on his company’s standard letterhead stating that to the best of his knowledge no product or material used on this project contains asbestos or lead. The statement shall include the name of the project and the contract number and shall be signed by an officer of the company. The statement shall be furnished within 10 calendar days of the Substantial Completion date. Submission of this statement is a condition for final payment under the contract.

B. Verification: If the FAA suspects the presence of asbestos or lead, tests shall be performed on the material or product at the FAA’s expense. If it is determined that the product or material does contain asbestos or lead, then the contractor shall remove the product or material and replace at his own expense including the expense of the testing and any retesting that may be necessary.

C. Non – Compliance: If the Contractor fails to provide the above statement, then the FAA shall have a complete building survey performed by a qualified testing firm and the costs deducted from the contractor’s final payment.

1.28 MATERIAL SAFETY DATA SHEETS (MSDS):

A. The Contractor shall submit to the Contracting Officer Representative Material Safety Data Sheets (MSDS) for all materials and/or products utilized during the course of the project accomplishment. During the course of the project, both the Contracting Officer Representative and the Contractor shall routinely check products utilized on-site to ensure only products which have had MSDS submitted are utilized. Copies of all MSDS shall be turned over to the local FAA office for their records.

1.29 INITIAL SUBMITTALS

A. The following submittals are required to have FAA approval prior to Notice to Proceed.

1.	Section 01 00 00	LIST OF SUBCONTRACTORS, CERTIFICATE OF INSURANCE
2.	Section 01 32 00	CONSTRUCTION SCHEDULE
3.	Section 01 32 00.10	EARNED VALUE MANAGEMENT
4.	Section 01 32 33	PRE-CONSTRUCTION VIDEO
5.	Section 01 40 00	CONTRACTOR QUALITY CONTROL
6.	Section 01 52 16	SAFETY PLANS
7.	Section 01 71 33	PROTECTION OF WORK AND PROPERTY

1.30 KNOWLEDGE SHARING NETWORK (KSN) SITE

The FAA maintains a joint use internet site for the purpose of electronic communication with its Contractors. If it is a requirement to use this KSN site for submittals, RFI's and other communications with the government, the government will provide access and required passwords to allow access to this site.

1.31 UTILITY CONTACTS

Contractor shall be responsible for establishing and maintaining a list of the local utility contacts.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 01 00 00

SECTION 01 10 00 – SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Work covered by the Contract Documents.
2. Type of the Contract.
3. Work phases.
4. Work under other contracts.
5. Products ordered in advance.
6. FAA-furnished products.
7. Use of premises.
8. FAA's occupancy requirements.
9. Work restrictions.
10. Specification formats and conventions.
11. Permits and Fees
12. Insurance

1.2 DEFINITIONS

A. Contracting Officer’s Representative (COR): Individual authorized to receive and distribute information on the behalf of the Contracting Officer. Also referred to as the Contracting Officer’s Technical Representative (COTR) and/or Resident Engineer (RE) in some instances.

B. Recycled Content: The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

1. "Post-consumer" material is defined as waste material generated by households or by commercial, industrial, and institutional facilities in their role as end users of the product, which can no longer be used for its intended purpose.
2. "Pre-consumer" material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it.

C. Recycled Content: The percentage by weight of constituents that have been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process (pre-consumer), or after consumer use (post-consumer).

1. Spills and scraps from the original manufacturing process that are combined with other constituents after a minimal amount of reprocessing for use in further production of the same product are not recycled materials.

2. Discarded materials from one manufacturing process that are used as constituents in another manufacturing process are pre-consumer recycled materials.

1.3 ENVIRONMENTAL GOALS

A. Support implementation goals of federal policy and programs for sustainable building, in accordance with Executive Order 13423 – Strengthening Federal Environmental, Energy, and Transportation Management.

B. Comply with Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings.

1. Employ Integrated Design Principles.

   a. Integrated Design.
   b. Commissioning.

2. Optimize Energy Performance

   a. Energy Efficiency.
   b. Measurement and Verification.

3. Protect and Conserve Water.

   a. Indoor Water (conservation)
   b. Outdoor Water

4. Enhance Indoor Environmental Quality

   a. Ventilation and Thermal Comfort.
   b. Moisture Control.
   c. Daylighting.
   d. Low-Emitting Materials.
   e. Protect Indoor Air Quality during Construction.

5. Reduce Environmental Impact of Materials.

   a. Recycled Content.
   b. Biobased Content.
   c. Construction Waste.
   d. Ozone Depleting Compounds.

1.4 WORK COVERED BY CONTRACT DOCUMENTS

A. Project Identification: Fort Lauderdale International Airport Traffic Control Tower (ATCT) Facility major improvements (FLL).

B. FAA's Lead Project Engineer: Joshua Blighton (AJW-2E1D) FAA Eastern Service Area, 1701 Columbia Avenue, College Park, GA 30337

C. CO (Contracting Officer): TBD.

D. The Work includes, but may not be limited to, the following:

1. Replace cab, catwalk, and TRACON Base Building roofing
2. Repair of exterior elements at cab and catwalk on Airport Traffic Control Tower (ATCT)
3. Replacement of flooring in ATCT and TRACON buildings
4. Repainting of TRACON interior walls
5. Renovation of TRACON restroom area
6. Plumbing repairs
7. Update lightning protection system
8. Update the fire protection systems
9. Replace roof drains on Base Building
10. HVAC replacement in Base Building
11. All ancillary systems and work to provide a complete project as depicted on the drawings and specifications

1.5 TYPE OF CONTRACT

A. Project will be constructed under a firm fixed price contract awarded to a single contractor.

1.6 WORK PHASES

A. The Work shall be conducted in one phase. The Contractor will be responsible for determining the sequence of operation to maintain security of the airport and the construction site.

B. Before commencing Work, submit a schedule showing the sequence, commencement and completion dates, and move-in dates of FAA's personnel for all of the Work.

1.7 WORK UNDER OTHER CONTRACTS

A. General: Cooperate fully with separate contractors so work on those contracts may be carried out smoothly, without interfering with or delaying work under this Contract. Coordinate the Work of this Contract with work performed under separate contracts.

1.8 USE OF PREMISES

A. General: Contractor shall have limited use of premises for construction operations, including the affected areas of the ATCT and Base Building, during construction period. Contractor's use of premises is limited by FAA's need for uninterrupted operations and the right to perform work in affected areas.

B. Use of Site: Limit use of premises to areas within the ATCT Facility where the Contract limits are indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.

1. Contractor shall minimize dust, noise, and odors transferring to other parts of the ATCT. Use of temporary barriers and separate filter systems will be required. See Division 2 specification sections for more information.

1.9 FAA'S OCCUPANCY REQUIREMENTS

A. FAA Occupancy of Completed Areas of Construction: FAA reserves the right to occupy and to place and install equipment in completed areas of building, before Substantial Completion, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and partial occupancy shall not constitute acceptance of the total Work.

1. Subparagraphs below describe procedures and requirements necessary before partial occupancy of portions of Project.
2. COR will prepare a Certificate of Substantial Completion for each specific portion of the Work to be occupied before FAA occupancy.
3. Before partial FAA occupancy, mechanical and electrical systems shall be fully operational, and required tests and inspections shall be successfully completed. On occupancy, FAA will operate mechanical and electrical systems serving occupied portions of building. Contractor shall provide maintenance for one year after date of Substantial Completion.
4. On occupancy, FAA will assume responsibility for custodial service for occupied portions of building. Contractor shall provide maintenance for one year after date of Substantial Completion.

1.10 WORK RESTRICTIONS

A. Normal working hours are 0700 to 1600, Monday through Friday (except U.S. Federal holidays). Contractor requests to work outside normal working hours require COR approval. However, the COR has full discretion to approve or disapprove, or withdraw approval of requests. If the contractor desires to work outside normal hours (including Saturdays, Sundays, and holidays), he shall submit his written request to the COR at least 48 hours in advance. Some typical constraints on working outside normal working hours are:

1. The Contractor’s request must be made at least two days in advance (e.g., request received by close of business Wednesday for work on following Saturday). Prior to submitting the request, the Contractor must coordinate as needed (such as utility outages) and have all required people and materials for the work that will be performed.
2. A Contractor with quality or safety problems (as determined by the COR) will be restricted to normal working hours. Contractors may also not work time outside of normal working hours if they are not present on the job site during normal working hours.
3. A Contractor who fails to correct deficiencies within a reasonable time (as determined by the COR) will be restricted to normal working hours or may be allowed to work outside normal working hours only to correct those deficiencies.
4. The Contractor shall schedule his work to cause the least amount of interference to normal activities.

B. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by FAA or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by FAA or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated: Notify FAA COR not less than 10 days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without FAA and utility company written permission.

D. Nonsmoking Building: Smoking is not permitted during construction. Smoking is not permitted within the building or within 25 feet of entrances, operable windows, or outdoor air intake

E. Limits on Operations: The FAA has established moratorium dates for construction activity at critical facilities including the Ft Lauderdale (FLL) Airport. The intent is to minimize the possibility of any activity that may have an adverse impact on the ability of FAA to perform its operational activities. Moratorium dates may change without notice. The moratorium dates are generally:

September: Labor day weekend
November – Friday before Thanksgiving through Monday after Thanksgiving
December/January – Friday before Christmas through Monday after New Years
Week of February 1-5, 2021

All construction activity during moratorium periods must be approved in advance by the FAA. Submit items of work to be performed during moratorium dates no later than forty-five (45) days prior to the moratorium dates. Activities that have, in the sole opinion of the FAA, potential to negatively impact FAA operations will not be approved. A written waiver will be provided by FAA to the Contractor outlining the allowable work items. No additional time or cost will be allowed for such denial.

1.11 SPECIFICATION FORMATS AND MISCELLANEOUS PROVISIONS

A. Specification Format: The Specifications are organized into Divisions and Sections using the 50-division format and CSI/CSC's "MasterFormat" numbering system.

1. Section Identification: The Specifications use Section numbers and titles to help cross-referencing in the Contract Documents. Sections in these Specifications are in numeric sequence; however, the sequence is incomplete because all available Section numbers are not used. Consult the table of contents at the beginning of the Project Manual to determine numbers and names of Sections in the Contract Documents.
2. Division 01: Sections in Division 01 govern the execution of the Work of all Sections in the Specifications.

A. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:

1. Abbreviated Language: Language used in the Specifications and other Contract Documents is abbreviated. Words and meanings shall be interpreted as appropriate.

Words implied, but not stated, shall be inferred as the sense requires. Singular words shall be interpreted as plural and plural words shall be interpreted as singular where applicable as the context of the Contract Documents indicates.

2. Imperative mood and streamlined language are generally used in the Specifications. Requirements expressed in the imperative mood are to be performed by Contractor. Occasionally, the indicative or subjunctive mood may be used in the Section Text for clarity to describe responsibilities that must be fulfilled indirectly by Contractor or by others when so noted.

   a. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.

1.12 PERMITS AND FEES

A. Contractor is responsible for applying for utility services, obtaining required permits, and payment for any associated fees. Compliance is required with the conditions of all permits that have been issued. All fees must be paid by the Contractor.

B. Contractor is responsible for paying all charges associated with the construction of the project. This includes temporary and permanent utilities, permits, inspection fees, connection fees and equipment to be installed by utility companies. This allocation of financial responsibility applies to all utilities as well as City and County agencies and entities.

C. BUILDING PERMIT APPLICATIONS

1. Contractor will not be required to obtain a Building Permit from the City of Ft. Lauderdale.

D. CERTIFICATE OF OCCUPANCY

Contractor will not be required to obtain a Certificate of Occupancy from the City of Ft. Lauderdale.

1.13 INSURANCE

A. Insurance Requirements

The Contractor shall at its sole expense, procure and maintain in effect at all times during the performance of the Work insurance coverage with insurers and under forms of policies satisfactory to the FAA, and with limits not less than those set forth in the contract.

The contractor shall not commence work until he/she has obtained, and the Contracting Officer has approved, all insurance required within the contract, nor shall the contractor allow any subcontractor(s) to commence work on a subcontract until all similar insurance required of the subcontractor has been obtained and approved. The successful contractor shall be required to procure and maintain bodily injury, general liability, and property damage liability insurance in his/her own name as protection against damages to persons or property, including injury or death, which may result from his/her performance of the work.

The insurance required shall be written for not less than the limits of liability specified in the contract documents, or required by law, whichever is greater. The proof of insurance shall be furnished within ten (10) days from the date of the Notice of Award to the Contracting Officer for approval.

The insurance limits shall be maintained during the entire performance or contract work. No cancellations of any insurance, whether by the insurer or by the insured, shall be effective unless written notice thereof is given to the Contracting Officer at least thirty (30) days prior to the intended effective date thereof, which date has been expressed in the notice. Prior to the effective date of any such cancellation, the contractor shall take out new insurance to cover the policies so canceled. All insurance policies referred to shall be underwritten by companies authorized to do business in the state of construction. The Certification shall be an “ACCORD” certificate with the Contract number and job location identified.
Workmen's Compensation Insurance

This contract shall be void and of no effect unless the contractor secures compensation for the benefit of (and keep insured during the life of this contract) such employees as are required to be insured by the Workmen's Compensation Insurance Law in the state of construction. The contractor hereby agrees to secure such compensation in the manner prescribed by law. The contractor shall require any subcontractors similarly to provide Workmen's Compensation Insurance for all the latter's employees to be engaged in the work unless such employees are covered by the protection afforded by the contractor's Workmen's Compensation Insurance.

The above-indicated insurance shall be maintained during the entire performance of contract work. No cancellation of any insurance, whether by the insurer or by the insured, shall be effective unless written notice thereof is given to the Contracting Officer at least thirty (30) days prior to the intended effective date thereof, which date has been expressed in the notice. Prior to the effective date of any such cancellation, the contractor shall take out new insurance to cover the policies so canceled. All insurance policies referred to shall be underwritten by companies authorized to do business in the state of construction.

B. FAA Furnished Insurance

1. FAA is not maintaining any insurance on behalf of Contractor covering against loss or damage to the Work or to any other property of Contractor. In the event Contractor maintains insurance against physical loss or damage to Contractor’s construction equipment and tools, such insurance shall include an insurer's waiver of rights of subrogation in favor of FAA.

C. Notifications

1. In accordance with the submittal requirements outlined above, Contractor shall deliver the original and two (2) copies of the Certificate(s) of Insurance required by this clause and all subsequent notices of cancellation, termination and alteration of such policies to the CO with a copy to the COR.

D. Certificate of Insurance

1. The scope of coverage shall be shown on the certificate of insurance as “All operations of the Named Insured”.

1.14 SECURITY REQUIREMENTS

A. Personnel List: Contractor shall provide the Resident Engineer with a list of Contractor's personnel who will require access to the site. The list shall be kept current during project work. The Contractor shall provide all personnel with readily identifiable numbered badges during the period their access to the site is required. Badges shall be worn on outer clothes at all times when on airport property and at work in the site.

B. Security Investigation: If contractor needs access to active facility, Contractor's site superintendent shall submit to an FAA security background check and obtain an official FAA contractor ID badge. Other Contractor personnel may be subject to security investigation by FAA. Upon request by the Contracting Officer's Representative, the Contractor shall promptly complete all security forms provided by FAA.

C. Communication: The Contractor shall request through the COR, a meeting with the Airport Manager and Control Tower personnel to discuss planned Contractor activities in the controlled airport operation area.

D. Airport Requirements: Contractor must also meet all the Airport's security requirements for work at the airport. FAA will not provide escorts, communication, or transportation.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 01 10 00

SECTION 01 10 12 - CONSTRUCTION ADMINISTRATION FORMS

PART 1 – GENERAL

1.1 INDEX OF CONSTRUCTION ADMINISTRATION FORMS:

RFI Standard Form
Submittal Approval Form
FAA Life Safety System Inspection and Test Report
FAA Pre-Construction and Maintenance Project Safety and Health Checklist
FAA Fire Alarm System Certificate of Completion
Certificate of Substantial Completion (CoSC)
Substantial Completion Acceptance (SCA)
Partial Occupancy/Use Agreement (POUA)
Job Memorandum (JM)
Hot Work Permit
Lock Out/Tag Out Procedure (See Division 26)

SEE DIVISION 2 FOR ADDITIONAL FORMS ASSOCIATED WITH REMOVAL AND DISPOSAL OF HAZMAT

Contractor shall submit a copy of Airspace Form 7460.1 to COR
Contractor shall be responsible to follow up with airport division within 2 weeks of submission to verify receipt and ensure timely processing of the form.

PART 2 - EXECUTION

A. During the administration of the Contract, the Contractor will be required to complete various construction administration forms as a part of the Management System. These forms are identified above and will be issued at the Pre-Construction Conference. These forms may be revised during the construction period and the Contractor will be required to comply with any such revisions.

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U.S. Department of Transportation
Federal Aviation Administration

Failure To Provide All Requested Information May Delay Processing of Your Notice

Notice of Proposed Construction or Alteration

FOR FAA USE ONLY
Aeronautical Study Number
- - -

1. Sponsor *(person, company, etc. proposing this action) :*
Attn. of: ______
Name: ______
Address: ______
______
City: ______ State: ______ Zip: ______
Telephone: ______ Fax: ______

2. Sponsor's Representative *(if other than #1) :*
Attn. of: ______
Name: ______
Address: ______
______
City: ______ State: ______ Zip: ______
Telephone: ______ Fax: ______

3. Notice of: ☐ New Construction ☐ Alteration ☐ Existing

4. Duration: ☐ Permanent ☐ Temporary (months, days)

5. Work Schedule: Beginning ______ End ______

6. Type: ☐ Antenna Tower ☐ Crane ☐ Building ☐ Power Line ☐ Landfill ☐ Water Tank ☐ Other ______

7. Marking/Painting and/or Lighting Preferred:
☐ Red Lights and Paint ☐ Dual - Red and Medium Intensity White
☐ White - Medium Intensity ☐ Dual - Red and High Intensity White
☐ White - High Intensity ☐ Other ______

8. FCC Antenna Structure Registration Number *(if applicable):*
______

9. Latitude: ______° ______' ______. ______"

10. Longitude: ______° ______' ______. ______"

11. Datum: ☐ NAD 83 ☐ NAD 27 ☐ Other ______

12. Nearest: City: ______ State: ______

13. Nearest Public-use (not private-use) or Military Airport or Heliport:
______

14. Distance from #13. to Structure: ______

15. Direction from #13. to Structure: ______

16. Site Elevation *(AMSL):* ______**ft.**

17. Total Structure Height *(AGL):* ______**ft.**

18. Overall height (#16. + #17.) *(AMSL):* ______**ft.**

19. Previous FAA Aeronautical Study Number (if applicable):
______ - OE

20. Description of Location: (Attach a USGS 7.5 minute Quadrangle Map with the precise site marked and any certified survey.)

21. Complete Description of Proposal:

this form to be applied on-line at:

https://oeaaa.faa.gov/oeaaa/external/puntal.jsp

Frequency/Power (kW)	

Notice is required by 14 Code of Federal Regulations, part 77 pursuant to 49 U.S.C., Section 44718. Persons who knowingly and willingly violate the notice requirements of part 77 are subject to a civil penalty of $1,000 per day until the notice is received, pursuant to 49 U.S.C., section 46301 (a).

I hereby certify that all of the above statements made by me are true, complete, and correct to the best of my knowledge. In addition, I agree to mark and/or light the structure in accordance with established marking and lighting standards as necessary.

Date	Typed or Printed name and Title of Person Filing Notice	Signature

Please Type or Print on This Form
FAA Form 7460-1 (2-99) Supercedes Previous Edition
Form Approved OMB No. 2120-0001
NSN: 0052-00-012-0008

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Federal Aviation Administration

Request For Information No. 000

Title: _____

From:	**Project:**		**To:**
Contractor	**JOB TITLE**		
Contractor address	**Job Location**		
	Contract:		
Phone:			**Phone:**
Fax:			**Fax:**
Contact:			**RE:**
Drawing or Spec:	**Date Started:**	**Priority: Normal**	Potential Cost Impact? ☐ Yes ☐ No
	Date Required:		Potential Schedule Impact? ☐ Yes ☐ No
Attachments? No	**Date Completed:**		If yes to either, explain below.

Question (Include Potential Impacts):

Response:

By: , FAA

Date:

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APPROVAL OR DISAPPROVAL OF CONTRACTOR'S MATERIALS OR SHOP DRAWINGS	DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION

1. TO: Contractor Address Tel: Fax: ATTN:	2. DATE CONTRACTOR'S SUBMITTAL RECEIVED:	3. DATE SUBMITTAL RETURNED:
	4. GOV'T TRANS. NO.	5. CONTRACTOR'S TRANS. NO.
	6. PROJECT NAME	
	7. CONTRACT NUMBER	

8. TRANSMITTAL REFERENCE TO CONTRACT DRAWINGS and/or SHOP DRAWINGS

9. TRANSMITTAL REFERENCE TO CONTRACT DRAWINGS AND PARAGRAPH NUMBER and/or CHANGE ORDER NUMBER

10. FACTS:

Gentlemen: We are returning herewith the following Submittal Data:

A. ITEM NO.	B. NO. COPIES	C. NAME OF SUPPLIER	D. TYPE OF MATERIAL OR EQUIPMENT	E. APPROVAL AS SUBMITTED	E. APPROVAL AS NOTED*	F. NOT APPROVED †	F. REVISE AND RESUBMIT
				☐	☐	☐	☐
				☐	☐	☐	☐
				☐	☐	☐	☐
				☐	☐	☐	☐
				☐	☐	☐	☐
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				☐	☐	☐	☐
				☐	☐	☐	☐
				☐	☐	☐	☐
				☐	☐	☐	☐
				☐	☐	☐	☐

G. REMARKS

H. STIPULATIONS

*Data marked "Approved as Noted" is satisfactory, contingent upon contractor acceptance of corrections and/or notations, and if accepted does not require re-submittal.

†Data marked "Not Approved" does not meet job requirements, and contractor must re-submit on proper basis.

Approval of Data does not obviate Contractor Responsibility for correct take-off or installation clearance.

Carbon Copies Transmitted To:

Sincerely,

Contracting Officer's Representative

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FAA Life Safety System Inspection & Test Report

PART 1 FIRE SYSTEM LOCATION, NOTIFICATION OF TEST & VISUAL INSPECTION

PROTECTED PROPERTY:

PERSON RESPONSIBLE: ______________________________ TITLE: ____________________________________
PHONE: ____ FAX: ___________________________________

Check each box that applies to the fire system being tested.

☐ STANDARD ATCT
☐ NON-STANDARD ATCT
☐ SMO
☐ SSC
☐ AFSS
☐ PROPERTY FAA OWNED
☐ PROPERTY FAA LEASED
☐ ARSR SITE
☐ SITE OCCUPIED
☐ SITE UNOCCUPIED
OTHER ____

NOTIFICATION PRIOR TO FIRE SYSTEM TESTING:
Notify the following Individuals and/or Office of the fire system test.

☐ FIRE DEPARTMENT
☐ A. F. MANAGER
☐ TERMINAL MANAGEMENT
☐ CENTRAL STATION
☐ SMO SAFETY OFFICER
☐ AIR TRAFFIC MANGER
☐ BUILDING OCCUPANTS
☐ REGION SAFETY MANAGER
☐ AIRPORT MANAGEMENT
OTHER

VISUAL INSPECTION OF SYSTEM PRIOR TO TESTING:
Visually inspect the following Prior to Testing.

☐ CONTROL PANEL(S)
☐ PANEL SWITCHES
☐ PRESSURIZATION FAN(S)
☐ BATTERY CHARGER TEST
☐ ELEVATOR EQUIPMENT
☐ DACT
☐ REMOTE DETECTOR INDICATOR
☐ SYSTEM MODIFICATIONS
☐ PANEL LIGHTS
☐ SYSTEM BATTERIES
☐ LOAD VOLTAGE
☐ HVAC SYSTEM(S)
☐ AUDIO DEVICES
☐ SUPPRESSION SYSTEM(S)
☐ SYSTEM RECORDS
☐ EMERGENCY GEN.
☐ PULL STATIONS
☐ POWER SUPPLIES
☐ SMOKE DETECTORS
☐ STROBES
☐ REMOTE ANNUNCIATOR
☐ PRINTER
☐ RECORD DRAWINGS
☐ OPERATORS MANUAL
OTHER ____

Make notations below in the comment section for items which are deficient and noted during the visual inspection. Additional space is available for notation of deficiencies in each section below.

WARNING:

IF THIS SYSTEM PROVIDES DETECTION AND/OR CONTROL FOR AUTOMATIC SUPPRESSION, THE AGENT RELEASE PORTION OF THE SUPPRESSION SYSTEM(S) *MUST* BE *DISABLED* PRIOR TO TESTING *ANY* SYSTEM INITIATING DEVICES TO PREVENT INADVERTENT AGENT RELEASE!

THIS FACILITIES HVAC SHUTDOWN, ELEVATOR RECALL AND PRESSURIZATION FAN SYSTEMS MUST BE TESTED ANNUALLY, TO INSURE PROPER OPERATION. AVOID UNNECESSARY CYCLING OF THESE SYSTEMS AND DISABLE THE CONTROLLING RELAYS OR ACTIVATE THE PREPROGRAMMED BY-PASS SWITCH AFTER INITIAL TESTING AND VERIFICATION OF EACH.

PART 2 FIRE SYSTEM PANEL DATA & SERVICE INFORMATION

LOCATION OF THE FIRE ALARM PANEL/FIRE COMMAND CENTER:

SYSTEM MANUFACTURER

MODEL NO.: DATE SYS. COMMISSIONED:

SERVICE COMPANY: PHONE: FAX:

ADDRESS:

CONTACT: SERVICE CONTRACT: □ YES NO

NICET CERT. NO.: NICET LEVEL: STATE LICENSE NO.:

DATE SERVICE STARTED: DATE SERVICE DEFAULTS:

DATE OF LAST SYSTEM SERVICE: DATE OF LAST SYSTEM TEST:

DOES THE PANEL APPEAR TO BE OPERATING PROPERLY (NORMAL CONDITION)	☐ YES	☐ NO
IS THE FIRE PANEL A POWER LIMITED SYSTEM	☐ YES	☐ NO
ARE ALL CIRCUITS SUPERVISED	☐ YES	☐ NO
IS A SYSTEM SMOKE DETECTOR PROVIDED TO PROTECT THE PANEL	☐ YES	☐ NO
IS ADEQUATE BATTERY BACK-UP PROVIDED AS PER NFPA 72	☐ YES	☐ NO
IS SURGE SUPPRESSION PROVIDED AT THE AC CIRCUIT BREAKER	☐ YES	☐ NO
IS THE 110 VOLT CIRCUIT PERMANENTLY LABELED "FIRE ALARM"	☐ YES	☐ NO
IS AN EMERGENCY GENERATOR PROVIDING BACK-UP POWER	☐ YES	☐ NO
IS THERE MORE THAN ONE SYSTEM PANEL INSTALLED	☐ YES	☐ NO

PANEL POWER SUPPLY, PRIMARY (MAIN), NOMINAL VOLTAGE _____________, AMPS __________________

OVERCURRENT PROTECTION, TYPE______________, AMPS ______________, LOCATION __________________

POWER DISCONNECT MEANS _____________, LOCATION _______________, LOCKOUT ___________________

SECONDARY (STANDBY) POWER ______________ STORAGE BATTERY, AMP-HOUR RATING ______________

CALCULATED CAPACITY TO OPERATE SYSTEM, IN HOURS: 4 __________ 24 ___________ 60______________

BATTERY TYPE:

☐ DRY CELL ☐ NICKEL CADMIUM ☐ SEALED LEAD ACID ☐ LEAD ACID ☐ OTHER _________________

ENGINE GENERATOR DEDICATED TO THE FIRE ALARM SYSTEM POWER CIRCUIT ☐ YES ☐ NO

TRANSIENT SUPPRESION:

120V CIRCUIT DEVICE TYPE:	QTY.	LOCATION:
INITIATION CIRCUIT TYPE:	QTY.	LOCATION:
AUDIO CIRCUIT TYPE:	QTY.	LOCATION:
VISUAL CIRCUIT TYPE:	QTY.	LOCATION:
SIGNALING LINE CIRCUIT TYPE:	QTY.	LOCATION:
OTHER:		

A transient suppression device (listed for operation with the system) is required for each circuit that exits or enters a building. The device shall be mounted in a junction box at the point of exit and entry. Label each circuit being protected.

PART 1 AND 2 DEFICIENCIES NOTED AND/OR COMMENTS:

NOTE: The comment portions of this form are required to have an entry. If a deficiency does not exist then the Technician shall enter "A deficiency has not been noted." If more than one alarm panel exists, complete this form for each.

PART 3 DIGITAL ALARM COMMUNICATOR & MONITORING COMPANY

IS THIS FIRE ALARM SYSTEM MONITORED VIA A DACT	☐ YES	☐ NO
IS THE DACT A DUAL CHANNEL	☐ YES	☐ NO

IS THE SPRINKLER OR SUPPRESSION SYSTEM (IF EXISTING) MONITORED: ☐ YES ☐ NO
IS THE DACT A FOUR CHANNEL, DUAL LINE DACT (REQUIRED FOR SPRINKLER) ☐ YES ☐ NO
IS THE DACT POWER FROM THE CONTROL PANEL ☐ YES ☐ NO
IS THE POWER SUPERVISED ☐ YES ☐ NO
IS THERE A DEDICATED PRIMARY PHONE LINE ☐ YES ☐ NO
IS THERE A SECONDARY PHONE LINE ☐ YES ☐ NO

DACT MANUFACTURER: ____________________ MODEL NO.: ____________________
NAME OF CENTRAL STATION: ____________________ POINT OF CONTACT: ____________________
ADDRESS:____________________

ACCOUNT # ____________________ PHONE: __________ FAX:
DATE CONTRACT STARTED: ____________________ DATE CONTRACT DEFAULTS: __________
LIST NAME AND PHONE NO. OF EACH PERSON(S) TO BE CONTACTED BY THE CENTRAL STATION:

____
____
____

NOTED DACT DEFICIENCIES AND/OR COMMENTS:

____
____
____
____

NOTE: The comment portions of this form are required to have an entry. If a deficiency does not exist then the Technician shall enter "A deficiency has not been noted.

PART 4 INITIATION DEVICES AND INITIATING. OR SIGNALING CIRCUIT TYPE

Initiating devices, are those system(s) devices which *initiate* an alarm or supervisory condition. An Initiating Device Circuit (IDC) is a *hard-wired* (non-addressable) circuit(s), which employees initiating (non-addressable) devices, to send an alarm condition to the fire panel. A Signaling Line Circuit (SLC) is a circuit(s) which employees *addressable* initiating devices (for the purpose of this section). A fire system configuration may consist of both *hard-wired* and *addressable* circuits. Additional information is available to complete this section, in the NFPA 72, Section 23.5 and 12.3 for IDC hardwired circuits and Section 23.6 and 12.3 for SLC addressable signaling line circuits. Check those boxes below that apply to the initiating devices and circuits. PART 6 of this report is for panel to panel communications and/or LCD/Printer communications. In filling out the device chart below wire class should be either "Class A", "Class B", or "Class X".

ADDRESSABLE SYSTEM, **SIGNALING LINE CIRCUIT (SLC):**

☐ ADDRESSABLE ☐ (CLASS A) ☐ (CLASS B) ☐ (CLASS X)

TOTAL QTY. OF ADDRESSABLE CIRCUITS __________ EACH CIRCUIT CAPACITY (MAX) __________
QTY. OF SPARE ADDRESSABLE POINTS __________ ON CIRCUIT(S) ____________________
PANEL CAPACITY FOR ADDITIONAL MODULES ____________________

ADDRESSABLE SYSTEM SOFTWARE:

REVISION NUMBER: ____________________ REVISION DATE: ____________________

FAA Life Safety System Inspection & Test Report

ALARM INITIATING, SUPERVISORY & CONTROL DEVICE INFORMATION:

Information of the fire alarm Circuits, Class and Style is noted below. For additional guidance regarding the characteristics of each circuit noted, refer to 12.3 and 23.6 for SLC in NFPA 72.

SYSTEM POINT OR DEVICE TYPE	QUANTITY OF DEVICE TYPE:	WIRE CLASS: (A, B, or X)	CIRCUIT NUMBER:
ADDRESSABLE SYSTEM:			
MANUAL STATIONS	____	_____	_________
IONIZATION DETECTORS	____	_____	_________
PHOTOELECTRIC DETECTORS	____	_____	_________
ION DUCT DETECTORS	____	_____	_________
PHOTO DUCT DETECTORS	____	_____	_________
FIXED TEMP HEAT DETECTORS	____	_____	_________
R OF R HEAT DETECTORS	____	_____	_________
RATE COMPENSATED DETECTORS	____	_____	_________
MONITOR OR CONTROL MODULE FOR:	____	_____	_________
FIXED TEMP HEAT DETECTOR	____	_____	_________
BEAM DETECTORS	____	_____	_________
UV/IR DETECTORS	____	_____	_________
COMBINATION DETECTOR	____	_____	_________
WATERFLOW ALARM SWITCH	_____	_____	__________
WATER SUPERVISORY SWITCH	____	_____	_________
POST INDICATOR VALVE	____	_____	_________
WATER SYSTEM AIR PRESSURE	____	_____	_________
SUPPRESSION PANEL ALARM	____	_____	_________
SUPPRESSION PANEL TROUBLE	____	_____	_________
SUPPRESSION PANEL RELEASE	____	_____	_________
SUPPRESSION PRESSURE SWITCH	____	_____	_________
SUPPRESSION SUPERVISORY	____	_____	_________
SECURITY CONTACT	____	_____	_________
STAIRWELL PRESSURIZATION FAN ON	____	_____	_________
STAIRWELL PRESSURIZATION FAN OFF	____	_____	_________
STAIRWELL PRESSURIZATION MANUAL	____	_____	_________
EMERGENCY GENERATOR ON	____	_____	_________
EMERGENCY GENERATOR OFF	____	_____	_________
ELEVATOR RECALL (PRIMARY)	____	_____	_________
ELEVATOR RECALL (SECONDARY)	____	_____	_________
FIRE PUMP POWER	____	_____	_________
FIRE PUMP TROUBLE	____	_____	_________
FIRE PUMP AUTO.	____	_____	_________
FIRE PUMP RUNNING	____	_____	_________
FIRE PUMP OFF	____	_____	_________
FIE PUMP PHASE REFFERSAL	____	_____	_________
OTHER ALARM_____________________	____	_____	_________
OTHER TROUBLE___________________	____	_____	_________
OTHER SUPERVISORY ______________	____	_____	_________
OTHER ____________________________	____	_____	_________

HARDWIRED SYSTEM, INITIATING DEVICE AND SUPERVISORY CIRCUIT (IDC):

☐ HARDWIRED ☐ CLASS A ☐ CLASS B

TOTAL QTY. OF HARDWIRED CIRCUITS _________________ QTY. OF SPARE CIRCUITS ___________________

PANEL CAPACITY FOR ADDITIONAL ZONE MODULES____

FAA Life Safety System Inspection & Test Report

ALARM INITIATING & SUPERVISORY DEVICE INFORMATION:

Information of the fire alarm Circuits, Class and Style is noted below. For additional guidance regarding the characteristics of each circuit noted, refer to 12.3 and 23.5 for IDC in NFPA 72.

SYSTEM POINT OR DEVICE TYPE TYPE:	**QUANTITY OF DEVICE** (A or B)	**WIRE CLASS:** (Letter)	**CIRCUIT OR ZONE**
HARDWIRED SYSTEM:			
MANUAL STATIONS	______	______	______________
IONIZATION DETECTORS	______	______	______________
PHOTOELECTRIC DETECTORS	______	______	______________
ION DUCT DETECTORS	______	______	______________
PHOTO DUCT DETECTORS	______	______	______________
FIXED TEMP HEAT DETECTORS	______	______	______________
R OF R HEAT DETECTORS	______	______	______________
RATE COMPENSATED DETECTORS	______	______	______________
FIXED TEMP HEAT DETECTOR	______	______	______________
BEAM DETECTORS	______	______	______________
UV/IR DETECTORS	______	______	______________
COMBINATION DETECTOR	______	______	______________
WATERFLOW ALARM SWITCH	______	______	______________
WATER SUPERVISORY SWITCH	______	______	______________
POST INDICATOR VALVE	______	______	______________
WATER SYSTEM AIR PRESSURE	______	______	______________
SUPPRESSION PANEL ALARM	______	______	______________
SUPPRESSION PANEL TROUBLE	______	______	______________
SUPPRESSION PANEL RELEASE	______	______	______________
SUPPRESSION PRESSURE SWITCH	______	______	______________
SUPPRESSION SUPERVISORY	______	______	______________
SECURITY CONTACT	______	______	______________
STAIRWELL PRESSURIZATION FAN ON	______	______	______________
STAIRWELL PRESSURIZATION FAN OFF	______	______	______________
STAIRWELL PRESSURIZATION MANUAL	______	______	______________
EMERGENCY GENERATOR ON	______	______	______________
EMERGENCY GENERATOR OFF	______	______	______________
ELEVATOR RECALL (PRIMARY)	______	______	______________
ELEVATOR RECALL (SECONDARY)	______	______	______________
FIRE PUMP POWER	______	______	______________
FIRE PUMP TROUBLE	______	______	______________
FIRE PUMP AUTO	______	______	______________
FIRE PUMP RUNNING	______	______	______________
FIRE PUMP OFF	______	______	______________
FIE PUMP PHASE REFFERSAL	______	______	______________
OTHERALARM______________________	______	______	______________
OTHER TROUBLE____________________	______	______	______________
OTHER SUPERVISORY_______________	______	______	______________
OTHER______________________________	______	______	______________

NOTED SIGNALING DEVICE CIRCUIT (SLC), INITIATING DEVICE CIRCUIT (IDC) AND INITIATING DEVICE OR SUPERVISORY DEVICE DEFICIENCIES AND COMMENTS:

____

____

____

____

NOTE: The comment portions of this form are required to have an entry. If a deficiency does not exist then the Technician shall enter "A deficiency has not been noted".

PART 5 NOTIFICATION APPLIANCE CIRCUIT (NAC)

Notification Appliance Circuits (NAC) are those system circuits that employ notification appliance device(s) which provides both *audio* and *visual* notification, in the event of a fire. Section 12.3 and 23.7 of the NFPA 72, shall provide additional information in regards to circuit performance capabilities. Refer to Section 12.3 for NAC Class configurations. Other documents that effect the fire system audio/visual devices are as follows:

1. ANSI S3.41, *American National Standard Audible Emergency Evacuation Signal,* which requires that the fire alarm signals be *distinctive* in sound from other signals and not to be used for any other purpose. See NFPA 72, 18.4.2

2. The use of the three-pulse temporal pattern fire alarm evacuation signal has been adopted by both the American National Standard, ANSI S3.41 (as referenced above) and International Standard, ISO 8201, *Audible Emergency Evacuation Signal.* Information regarding performance, location, and mounting of Notification Appliance(s) is available in NFPA 72, Chapter 6. For control and power supplies refer to Chapter 1 and Chapter 3.

VISUAL STROBE DEVICES:

Strobes shall be UL *labeled* and the label shall indicate compliance with UL 1971, *Signaling Applications for the Hearing Impaired.* Further details are available in the NFPA 72, Chapter 18.4, regarding strobe flash rate and intensity. Spacing information, for strobe placement in room, is available in the NFPA 72 Paragraph 18.5.4, Tables 18.5.4.3.1(a), 18.5.4.3.1(b), and Figures 18.5.4.3.1. Spacing information for strobe placement in corridors is available in Chapter 18.5.4.4.

STROBE CIRCUIT NUMBER	**STROBE CIRCUIT CLASS:** (A or B)	**IS CIRCUIT SUPERVISED AS REQUIRED PER NFPA 72:**	**QTY. OF STROBES PER CIRCUIT:**	**POWER** (AMPS) **REQUIRED TO DRIVE CIRCUIT:**
# 1	_______	_______	___	_______
# 2	_______	_______	_______	_______
# 3	_______	_______	_______	_______
# 4	_______	_______	_______	_______
# 5	_______	_______	_______	_______
# 6	_______	_______	_______	_______
# 7	_______	_______	_______	_______
# 8	_______	_______	_______	_______
# 9	_______	_______	_______	_______
# 10	_______	_______	_______	_______
# 11	_______	_______	_______	_______
# 12	_______	_______	_______	_______
# 13	_______	_______	_______	_______
# 14	_______	_______	_______	_______
# 15	_______	_______	_______	_______
# 16	_______	_______	_______	_______
# 17	_______	_______	_______	_______
# 18	_______	_______	_______	_______
# 19	_______	_______	_______	_______
# 20	_______	_______	_______	_______
# 21	_______	_______	_______	_______
# 22	_______	_______	_______	_______
# 23	_______	_______	_______	_______
# 24	_______	_______	_______	_______
# 25	_______	_______	_______	_______
# 26	_______	_______	_______	_______
# 27	_______	_______	_______	_______
# 28	_______	_______	_______	_______
# 29	_______	_______	_______	_______
# 30	_______	_______	_______	_______

TOTAL POWER (IN AMPS) CONSUMED BY THE VISUAL CIRCUIT(S)	_______
POWER (IN AMPS) AVAILABLE AT THE CONTROL PANEL FOR THE CIRCUIT(S)	_______
IS ADEQUATE BATTERY BACK-UP PROVIDED FOR THE CIRCUITS LISTED	☐ YES ☐ NO
ARE THE CIRCUITS LISTED POWERED BY ONE FIRE CONTROL PANEL	☐ YES ☐ NO
ARE ADDITIONAL PANELS EMPLOYED TO PROVIDE CIRCUIT POWER	☐ YES ☐ NO
ARE THE ADDITIONAL PANELS SUPERVISED BY THE MAIN PANEL	☐ YES ☐ NO
ARE THE ADDITIONAL PANELS PROTECTED WITH A SYSTEM DETECTOR	☐ YES ☐ NO
ARE THE ADDITIONAL PANELS EQUIPPED WITH BATTERY BACK-UP	☐ YES ☐ NO
IS ADEQUATE BATTERY BACK-UP PROVIDED FOR THE PANELS	☐ YES ☐ NO

ARE THE ADDITIONAL PANELS EQUIPPED WITH SURGE SUPPRESSION	☐ YES	☐ NO
ARE STROBES INSTALLED THROUGHOUT THE FACILITY*	☐ YES	☐ NO
ARE STROBES INSTALLED IN ONLY PART OF THE FACILITY	☐ YES	☐ NO
ARE THE STROBES INCANDESCENT (FLASHLIGHT TYPE BULB)	☐ YES	☐ NO
ARE THE STROBES XENON TYPE (ELONGATED TYPE BULB)	☐ YES	☐ NO
ARE THE STROBES COMPLIANT WITH UL 1971 (LABELED)	☐ YES	☐ NO

* Strobe placement shall comply with the above referenced sections of the NFPA 72 as applicable.
For additional circuits fill out another page 8 of this form and attach.

NOTED VISUAL APPLIANCE AND/OR NOTIFICATION APPLIANCE CIRCUIT DEFICIENCIES AND COMMENTS:

NOTE: The comment portions of this form are required to have an entry. If a deficiency does not exist then the Technician shall enter "A deficiency has not been noted.

AUDIO DEVICES AND CIRCUITS:

Tower Cabs, TRACON Rooms and Traffic Control Rooms which must remain in operation during the investigation period of a reported fire, shall not be required to meet the dBA levels of Audio notification noted in NFPA 72, Chapter 18.4.3.1. Chimes and/or Visual devices shall be employed in those areas. Notification Appliance Circuits in the noted areas, shall be programmed to be silenced, while the visual signals in the remainder of the facility continue. Visual notification circuits in the remainder of the facility shall continue to signal an alarm, until the Fire Alarm Control Panel, is clear of all fire conditions. Any subsequent Alarm from a fire initiation device shall resound the audio and visual devices.

FAA Life Safety System Inspection & Test Report

For areas of general occupancy, Audible signals shall have a sound level of not less than 75 dBA at a distance of 10 feet from the audio device. The sound level of the audio device shall be 15 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of at least 60 seconds (whichever is greater), measured 5 feet from above the floor in the occupiable area. The sound level of an audio device shall not exceed 110 dBA. Refer to NFPA 72, Chapter 18.4.8 for audio device location.

AUDIO CIRCUIT NUMBER	**AUDIO CIRCUIT CLASS:** (A or B)	**IS CIRCUIT SUPERVISED AS REQUIRED PER NFPA 72:**	**QTY. OF DEVICES PER CIRCUIT:**	**POWER** (AMPS) **REQUIRED TO DRIVE CIRCUIT:**
# 1	_______	_______	______	_________
# 2	_______	_______	______	_________
# 3	_______	_______	______	_________
# 4	_______	_______	______	_________
# 5	_______	_______	______	_________
# 6	_______	_______	______	_________
# 7	_______	_______	______	_________
# 8	_______	_______	______	_________
# 9	_______	_______	______	_________
# 10	_______	_______	______	_________
# 11	_______	_______	______	_________
# 12	_______	_______	______	_________
# 13	_______	_______	______	_________
# 14	_______	_______	______	_________
# 15	_______	_______	______	_________
# 16	_______	_______	______	_________
# 17	_______	_______	______	_________
# 18	_______	_______	______	_________
# 19	_______	_______	______	_________
# 20	_______	_______	______	_________
# 21	_______	_______	______	_________
# 22	_______	_______	______	_________
# 23	_______	_______	______	_________
# 24	_______	_______	______	_________
# 25	_______	_______	______	_________
# 26	_______	_______	______	_________
# 27	_______	_______	______	_________
# 28	_______	_______	______	_________
# 29	_______	_______	______	_________
# 30	_______	_______	______	_________

TOTAL POWER (IN AMPS) CONSUMED BY THE AUDIO CIRCUIT(S) _______
POWER (IN AMPS) AVAILABLE AT THE CONTROL PANEL FOR THE CIRCUIT(S) _______
IS ADEQUATE BATTERY BACK-UP PROVIDED FOR THE CIRCUITS LISTED ☐ YES ☐ NO
ARE THE CIRCUITS LISTED POWERED BY ONE FIRE CONTROL PANEL ☐ YES ☐ NO
ARE ADDITIONAL PANELS EMPLOYED TO PROVIDE CIRCUIT POWER ☐ YES ☐ NO
ARE THE ADDITIONAL PANELS SUPERVISED BY THE MAIN PANEL ☐ YES ☐ NO
ARE THE ADDITIONAL PANELS PROTECTED WITH A SYSTEM DETECTOR ☐ YES ☐ NO
ARE THE ADDITIONAL PANELS EQUIPPED WITH BATTERY BACK-UP ☐ YES ☐ NO
IS ADEQUATE BATTERY BACK-UP PROVIDED FOR THE THOSE PANELS ☐ YES ☐ NO
ADDITIONAL PANELS EQUIPPED WITH SURGE SUPPRESSION ☐ YES ☐ NO
ARE AUDIO DEVICES INSTALLED THROUGHOUT THE FACILITY * ☐ YES ☐ NO
ARE AUDIO DEVICES INSTALLED IN ONLY A PORTION OF THE FACILITY ☐ YES ☐ NO
ARE THE AUDIO DEVICES ALL OF THE SAME TYPE (HORN, BELLS, CHIMES, ETC) ☐ YES ☐ NO
ARE THE AUDIO DEVICES COMPLIANT WITH NFPA 72 ☐ YES ☐ NO
ARE THERE ANY SPARE AUDIO/VISUAL CIRCUITS AVAILABLE ON THE SYSTEM ☐ YES ☐ NO

* Note the exceptions allowed for Tower Cabs, TRACON Rooms, Control Rooms, etc.

For additional circuits fill out another page 10 and 11 of this form and attach.

NOTED AUDIO APPLIANCE AND/OR NOTIFICATION APPLIANCE CIRCUIT DEFICIENCIES AND COMMENTS:

NOTE: The comment portions of this form are required to have an entry. If a deficiency does not exist then the Technician shall enter "A deficiency has not been noted."

PART 6 REMOTE ANNUNCIATION TYPE & CIRCUIT

Check those boxes that apply.

☐ ADDRESSABLE ALPHA/NUMERIC
☐ HARDWIRED ALPHA/NUMERIC
☐ GRAPHIC ANNUNCIATOR
☐ HARDWIRED DIRECTORY ANNUNCIATOR
☐ CLASS A
☐ CLASS B
☐ SERIAL PRINTER(S) QTY. ___________________
☐ OTHER ______________________________________

ARE THE ANNUNCIATION DEVICES SUPERVISED	☐ YES	☐ NO
ENTRY EQUIPPED WITH AN ANNUNCIATOR	☐ YES	☐ NO
ANNUNCIATORS EQUIPPED WITH AN ALARM SILENCE	☐ YES	☐ NO
ANNUNCIATORS EQUIPPED WITH A SYSTEM RESET SWITCH	☐ YES	☐ NO

ADDRESSABLE SYSTEM ANNUNCIATORS EQUIPPED WITH ACKNOWLEDGE ☐ YES ☐ NO

NOTED REMOTE ANNUNCIATOR DEFICIENCIES AND COMMENTS:

____

____

NOTE: The comment portions of this form are required to have an entry. If a deficiency does not exist then the Technician shall enter "A deficiency has not been noted."

PART 7 VOICE EVACUATION SYSTEM CONTROLS AND DEVICES

VOICE EVACUATION SYSTEM CONTROLS:

VOICE PANEL LOCATION: ____
PANEL MANUFACTURER: ____________________________ MODEL NO.: ____________________________________

DOES THE PANEL APPEAR TO BE OPERATING PROPERLY (NORMAL CONDITION)	☐ YES	☐ NO
IS THE PANEL EQUIPPED WITH A MIC.	☐ YES	☐ NO
IS THE PANEL EQUIPPED WITH A FIRE PHONE SYSTEM	☐ YES	☐ NO
ARE EXTRA FIRE PHONES AVAILABLE QTY. __________	☐ YES	☐ NO
ARE ALL CIRCUITS SUPERVISED	☐ YES	☐ NO
IS A SYSTEM SMOKE DETECTOR PROTECTING THE PANEL	☐ YES	☐ NO
IS ADEQUATE BATTERY BACK-UP PROVIDED AS PER NFPA 72	☐ YES	☐ NO
IS SURGE SUPPRESSION PROVIDED AT THE 110 VOLT AC CIRCUIT	☐ YES	☐ NO
IS THE 110 VOLT CIRCUIT PERMANENTLY LABELED "FIRE ALARM"	☐ YES	☐ NO
IS THE SYSTEM EQUIPPED WITH BACK-UP AMPLIFIERS	☐ YES	☐ NO
IS THERE MORE THAN ONE VOICE SYSTEM PANEL	☐ YES	☐ NO
IS THE VOICE MESSAGE AUDIBLE	☐ YES	☐ NO
IS THE VOICE MESSAGE APPLICABLE TO THE FACILITIES NEEDS	☐ YES	☐ NO

PANEL POWER SUPPLY, PRIMARY (MAIN) , NOMINAL VOLTAGE ______________, AMPS ________________

OVERCURRENT PROTECTION, TYPE ___________, AMPS ________________, LOCATION ___________________

POWER DISCONNECT MEANS _______________, LOCATION _______________, LOCKOUT _________________

SECONDARY (STANDBY) POWER_______________STORAGE BATTERY, AMP-HOUR RATING ____________

CALCULATED CAPACITY TO OPERATE SYSTEM, IN HOURS: 4 ___________ 24 ___________ 60_____________

BATTERY TYPE:

☐ DRY CELL ☐ NICKEL CADMIUM ☐ SEALED LEAD ACID ☐ LEAD ACID ☐ OTHER ________

TRANSIENT SUPPRESSION:

120V CIRCUIT DEVICE TYPE:	QTY.	LOCATION:
AUDIO CIRCUIT TYPE:	QTY.	LOCATION:

Additional information regarding Voice system requirements is available in the NFPA 72, Chapter 24.

VOICE CIRCUIT NUMBER	**VOICE CIRCUIT CLASS:** (A or B)	**IS CIRCUIT SUPERVISED AS REQUIRED PER NFPA 72:**	**QTY. OF DEVICES PER CIRCUIT:**	**POWER** (WATTS) **REQUIRED TO DRIVE CIRCUIT:**
# 1	_______	_______	_________	
# 2	_______	_______	_________	________
# 3	_______	_______	_________	________
# 4	_______	_______	_________	________
# 5	_______	_______	_________	________

# 6	______	______	______	______
# 7	______	______	______	______
# 8	______	______	______	______
# 9	______	______	______	______
# 10	______	______	______	______
# 11	______	______	______	______
# 12	______	______	______	______
# 13	______	______	______	______
# 14	______	______	______	______
# 15	______	______	______	______
# 16	______	______	______	______
# 17	______	______	______	______
# 18	______	______	______	______
# 19	______	______	______	______
# 20	______	______	______	______
# 21	______	______	______	______
# 22	______	______	______	______
# 23	______	______	______	______
# 24	______	______	______	______
# 25	______	______	______	______
# 26	______	______	______	______
# 27	______	______	______	______
# 28	______	______	______	______
# 29	______	______	______	______
# 30	______	______	______	______

TOTAL POWER (IN WATTS) REQUIRED BY THE AUDIO CIRCUIT(S)	______	
POWER (IN WATTS) AVAILABLE AT THE VOICE PANEL FOR THE CIRCUIT(S)	______	
IS THE PANEL(S) SUPERVISED BY THE MAIN PANEL	☐ YES	☐ NO
IS ADEQUATE BATTERY BACK-UP PROVIDED FOR THE CIRCUITS LISTED	☐ YES	☐ NO
IS THE PANEL UL CROSS LISTED WITH THE FIRE CONTROL PANEL	☐ YES	☐ NO
IS THE PANEL EQUIPPED WITH MANUAL ZONE SELECTION SWITCHES	☐ YES	☐ NO
ARE ADDITIONAL PANELS EMPLOYED TO PROVIDE CIRCUIT POWER	☐ YES	☐ NO
ARE THE ADDITIONAL PANELS PROTECTED WITH A SYSTEM DETECTOR	☐ YES	☐ NO
ARE THE ADDITIONAL PANELS EQUIPPED WITH BATTERY BACK-UP	☐ YES	☐ NO
IS ADEQUATE BATTERY BACK-UP PROVIDED FOR THE THOSE PANELS	☐ YES	☐ NO
ADDITIONAL PANELS EQUIPPED WITH SURGE SUPPRESSION	☐ YES	☐ NO
ARE AUDIO DEVICES INSTALLED THROUGHOUT THE FACILITY *	☐ YES	☐ NO
ARE AUDIO DEVICES INSTALLED IN ONLY A PORTION OF THE FACILITY	☐ YES	☐ NO
ARE THE AUDIO DEVICES ALL POWER TAPPED THE SAME	☐ YES	☐ NO
ARE THERE ANY SPARE AUDIO CIRCUITS AVAILABLE ON THE SYSTEM	☐ YES	☐ NO

* Note Audio Devices are not to be installed in Tower Cabs, TRACON Rooms, Control Rooms, ETC.
For additional circuits fill out another page 13 of this form and attach.

NOTED AUDIO APPLIANCE AND/OR NOTIFICATION APPLIANCE CIRCUIT DEFICIENCIES AND COMMENTS:

____

____

____

____

____

____

NOTE: The comment portions of this form are required to have an entry. If a deficiency does not exist then the Technician shall enter "A deficiency has not been noted."

ADDITIONAL NOTATIONS OF THE ANNUAL FIRE SYSTEM INSPECTION AND TEST:

PART 8 ACCEPTANCE OF THE ANNUAL TEST & SIGNATURES

The Annual Inspection and Test of the above noted system(s), at the above noted FAA facility was performed as per the following: FAA ORDER, 6930.1B, Fire Prevention and Maintenance of Fire Protection Equipment, 6470.5A, Maintenance of Air Route Traffic Control Center Environmental Systems, 6480.8A, Maintenance of Airport Traffic Control Towers, 3900.19B, the Occupational Safety and Health Administration, the National Fire Protection Association, the National Fire Alarm Code, and the recommendations of the System Manufacturer. Upon completion this form shall be filed with each individual noted below and the FAA Regional Safety Office.

By Technician performing the annual test and inspection.

FAA Life Safety System Inspection & Test Report

Date: __________ Time:____________Signature:____

NICET Cert. #: __________ Printed Name and Title:____

Employed by: ________________________________ Phone Number: ____

State License or other Credentials: ____

FAA Individual whom witnessed the Fire System returned to normal operation.

Date: __________ Time:____________Signature:____

Printed Name and Title: ____

The individuals listed below, with their signatures, affirm that the Fire Life Safety System(s) noted above have been restored to an operational condition. If upon completion of this test an acceptable level of protection is in question, due to the deficiencies noted, then immediate action shall be taken to correct all the deficiencies. A retest of the defective device(s) or system operation(s) shall be required. Appropriate action shall be taken to insure the safety of the facilities individuals and operations during any system repairs and/or service. The responsible FAA Safety Individual shall provide the facilities Manager with Fire Watch training and information if required to insure a continued safe operation during the repairs and service.

By Technician performing the annual test and inspection.

Date: __________ Time:____________Signature:____

NICET Cert. #: __________ Printed Name and Title:____

Employed by: ________________________________ Phone Number: ____

State License or other Credentials: ____

FAA Individual whom witnessed the Fire System returned to normal operation.

Date: __________ Time:____________Signature:____

Printed Name and Title: ____

Authority having Jurisdiction and/or approving authority:
Name and Title: ______________________________Phone: _________________ FAX:_____________________

Representing: ________________________________Signature:____

Local Fire Department:_________________________ Phone:__________________FAX: _____________________

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Pre-Construction
Environmental and Occupational Safety and Health Checklist

INSTRUCTIONS FOR COMPLETING FAA FORM 3900-18

Section A. Purpose. FAA Form 3900-18, Pre-Construction Environmental and Occupational Safety and Health (EOSH) Checklist, is intended to be used to review construction, installation, and maintenance activities involving construction prior to commencement of work that potentially has EOSH impacts on NAS operations and employees. The organization that directly manages the construction project is responsible for completing the checklist. They shall coordinate with the appropriate District Office prior to commencement of the project. Actual work on the project (i.e., construction) may not be initiated prior to completion and review of the checklist. The form must be used, as appropriate, during critical phases of the work (e.g., during a mandatory pre-construction meeting). Emphasis should be placed on using this checklist as a tool to assess as well as reassess hazards as the work progresses.

1. Responsibilities: Responsibility for submitting the checklist may fall on several individuals depending on the work being performed.

a. For example, the District Office Manager will be responsible for District Office projects.

b. The engineer for Engineering Services projects.

c. The FMP manager for Field Maintenance Program (FMP) projects.

d. For turnkey projects managed by Headquarters organizations, the Headquarters program office will be responsible for submitting the checklist.

Section B. Work Summary Information. The individual/organization initiating the checklist will complete this portion of the checklist.

1. District Office: Name of the District Office.

2. Work Location: City, State, Airport, building, room within building.

3. Facility: Facility type, associated runway, facility ID.

4. Work Description: Provide a concise statement as to the nature of the work to be accomplished. Example: Asbestos abatement of the control room attic.

5. Originator of Work: This is the individual/organization responsible for initiating the work (e.g., project engineer, senior engineer, technical support office).

6. Planned Start Date: Provide the expected start date of the work.

7. Expected Completion Date: Provide the expected completion date of the work.

8. Contractor Contact: Provide the name and telephone/pager number for a contractor representative who has the authority to make decisions and implement stop work/change orders. If the work is being accomplished by an FAA employee(s) or FAA contract employee(s), provide the name, organization, and telephone/pager number of the on-site lead (e.g., work order carrier, etc.).

9. Project/Design Representative: Provide the name for the designer of the work (e.g., Engineering Services project engineer, District Office engineer, Headquarters program manager for turnkey projects).

10. COTR/Specialist: Provide the name, organization, and telephone/pager number of the on-site lead (e.g., COTR, work order carrier).

11. District Office EOSH Contact: Provide the name and telephone/pager number of the person responsible for the occupational safety and health/environmental program for the District Office (e.g., SECM, District Office OSH Professional).

12. Facility Representative: Provide the name and telephone number for an ATO representative at the facility who has the authority to make decisions for facility management.

Section C. Evaluation: The District Office Manager or designee will determine whether the work will have a potential EOSH impact to NAS operations. The District Office Manager or designee must sign and date this section. If there is an impact (yes), complete the checklist. If there is no impact, proceed to Section I, Distribution of Copies, for distribution only.

Section D. Facility Procedures: The individuals/organization performing the work, and their contractors, along with the facility POC, must review all applicable facility specific procedures and plans.

1. Asbestos Contingency Plan: Determine the responsibilities of the personnel doing the work in the event of an incident that requires implementation of the asbestos contingency plan.

2. Hazard Communications: The personnel performing the work must be made familiar with the facility hazard communication program. Information such as material safety data sheets (MSDS) must be shared between the facility and the personnel performing the work.

3. Lockout/Tagout (LOTO): The work must be performed in accordance with the facility LOTO program. Determine if the facility LOTO procedures require equipment to be locked out/tagged out by an FAA technician, or if the personnel performing the work will be allowed to LOTO the equipment.

4. Energized Work Permits: Applicable FAA facility, District Office, or regional energized work permits must be submitted by the individuals/organization performing the work, signed and posted at the work site. General note: All work permits should be included in this document (e.g., hot work permit, welding, cutting, brazing).

5. Emergency Plans: Describe the responsibilities, including the points of contact, in the event of an incident that requires implementation of the facility Occupant Emergency Plan.

6. Impacts to Fire Alarm and Suppression Systems: Identify the Fire Alarm and Suppression System and instructions to avoid unintentional impact to it. If the work involves intentional impact to the Fire Alarm and Suppression System, determine what coordination has to be done to ensure no disruption of the NAS. Determine what interim life safety measures will be required during the project.

7. Confined Space Entry: Describe the facility procedures used in and around confined spaces. In addition, describe specific procedures for permit-required confined space in and around where the work will take place.

8. Work at Heights: Describe procedures for working at elevated surfaces (catwalks, towers, roofs) that may require fall protection procedures or equipment.

9. Restricted Areas Due to OSH Concerns: Describe those areas of the facility that have restricted access due to safety and health hazards (e.g., asbestos regulated areas, noise).

10. Bloodborne Pathogens: Describe the facility procedures for dealing with emergency first aid situations and other trauma situations.

11. Other: The personnel performing the work should be made familiar with other facility programs, procedures, and requirements.

Pre-Construction
Environmental and Occupational Safety and Health Checklist

Section E. Activity Hazard: The individuals/organization performing the work, and their contractors, along with the facility POC, must identify potential OSH hazards that may be encountered during the accomplishment of the work. Determine the possibility of causing disruption of NAS operations.

1. Asbestos: Determine if known or assumed asbestos containing material will be impacted by this work.

2. Chemical, Gas, Fumes, Dust, Radiation: Determine if any products or methods will be used that may cause odors or vapors (from chemicals volatizing or biological agents), fumes (from welding or burning), excessive dust (e.g., sanding, grinding), or radiation (e.g., heat sources, light sources such as lasers, ionizing radiation sources such as X-ray equipment).

3. Storage of Hazardous Materials: Determine if substances that exist at the facility may be impacted and what substances may be brought into the facility, which may have an impact on the facility and/or occupants.

4. Impact on HVAC System: Determine whether the environmental control elements of the facility may be impacted by the accomplishment of the work.

5. Equipment Removal/Installations: Determine if work activities will cause disturbance of excessive dust, e.g. disturbance of equipment, which has been in place for a long time.

6. Fire Protection: Determine if work activities will impact fire protection systems and procedures at the facility (e.g., blocking egress, removing fire stopping, impacting fire rated barriers).

7. Impact to Integrity of Fire Alarm/Suppression System: Identify the Fire Alarm and Suppression System and instructions to avoid unintentional impact to it. If the work involves intentional impact to the Fire Alarm and Suppression System, determine what coordination has to be done to ensure no disruption of the NAS. Determine what interim life safety measures will be required during the project.

8. Lead Exposure: Determine if activities will expose FAA/contract employees to lead dust, lead fumes or other exposure to lead from known or assumed lead containing material during the construction project.

9. Electrical Safety: Determine if work activities will expose FAA employees to electrical safety hazards (e.g., open electrical panel doors, exposed energized conductors, energized work).

10. Noise: Determine if work activities will expose FAA employees to excessive noise.

11. Walking Working Surfaces: Determine if work activities will expose FAA employees to tripping, slip and fall hazards, e.g. open panels in a raised floor, uneven floors, raised or loose carpeting, stairs, wet floors, etc.

12. Work Above Equipment/People: Determine if work activities will expose FAA employees to objects dropped from above.

13. Water Quality/Sanitation: Determine if work activities may cut off or contaminate the facility's potable water system.

14. Cranes/Rigging/Hoisting: Determine if work activities will expose FAA employees to hazards associated with rigging, hoisting and cranes.

15. Lighting: Determine if work activities will create insufficient lighting for FAA employees.

16. Machinery and Mechanized Equipment: Determine if work activities may expose FAA employees to hazards such as being struck by, caught in, or injured by machinery and mechanized equipment.

17. Excavation: Determine if work activities performed near facilities may cause catastrophic failure of a NAS facility.

18. Other: Other work activities that may impact NAS operations and employees.

Pre-Construction
Environmental and Occupational Safety and Health Checklist

Section F. Site Safety and Health - Controls. Ensure that measures and controls to address applicable site safety and health risks (e.g., through discussions, available site safety plans, or other applicable documents) have been identified. If a hazard has been identified in Section E, Activity Hazard, briefly describe the controls to be used.

1. Identify issues/hazards in Section E, Activity Hazard.

2. "Has this been addressed in the site safety plan?" – The purpose of this column is to review the site safety plan for the work with regard to any hazards identified in Section E, Activity Hazard.

3. "Description of Controls" – The purpose of this column is to very briefly describe the controls in place for addressing each hazard.

Section G. Site Walk-Through: Following review of all applicable facility procedures, activity hazards and applicable control measures, the personnel performing the work must participate in a walk-through of the area of the facility where the work will be accomplished, led by a facility representative. The purpose of the walk-through is to allow the personnel performing the work to be introduced to the facility and the potential hazards as referenced in Sections E and F. It also allows the personnel performing the work to become familiar with the facility with respect to the work being done and awareness of the method of implementation of the various emergency plans. The time, date, and personnel present for the walk-through must be recorded in Section G.

Section H. Review Information. This form should be reviewed by those individuals identified below, as appropriate, during design of the project, during pre-bid conferences, prior to the beginning of work (preferably at or prior to the pre-construction conference) and periodically throughout the completion of the project.

1. Originator: This is the individual/organization responsible for initiating the work (e.g., project engineer, senior engineer, technical support office) or the organization directly managing the day-to-day activities in the construction project.

2. Contractor/Installation Crew Lead/Specialist: These are the individuals performing the work who have the authority to make decisions and implement stop work/change orders. If the work is being accomplished by an FAA employee or an FAA contract employee, the employee should sign the form and provide a routing symbol and platform title.

3. District Office Manager or designee: This person must be the District Office Manager or designee. The designee may be the Contracting Officer's Technical Representative, SSC Manager, or other party.

Section I. Distribution of Copies: The form must be signed and copies forwarded to the individuals identified below.

1. District Office Manager.

2. SECM (Safety and Environmental Compliance Manager) or District Office EOSH Professional.

3. Engineering Services EOSH (Environmental and Occupational Safety and Health) Coordinator.

4. Engineering Services Manager.

5. Engineering Services Project Engineer.

6. Contracting Officer.

Pre-Construction
Environmental and Occupational Safety and Health Checklist

Section A. Purpose

This checklist is intended to review construction, installation and non-routine maintenance activities, prior to commencement, that potentially have occupational safety and health related impacts on NAS operations and employees. This tool must be used, as appropriate, during critical phases of the work (e.g., the pre-construction meeting, prior to commencement of work, etc.). Emphasis should be placed on using this checklist as a tool to assess as well as reassess hazards as the work progresses.

Section B. Work Summary Information

The purpose of this section is to provide a brief description of the construction project and/or specific maintenance tasks, and identify key personnel responsible for project completion. Fill in the requested site-specific information. Indicate if this work will occur in or adjacent to an occupied space (e.g., equipment room, ATCT cab, etc.). Note: Provide further explanation of activities on additional sheets if necessary.

1. District Office: ____________________
2. Work Location: ____________________
3. Facility: ____________________
4. Work Description: ____________________

____

____

5. Planned Start Date: ____________
6. Expected Completion Date: ____________
7. Contractor Contact: Name: ____________ Phone: ____________
8. Project/Design Representative: Name: ____________ Phone: ____________
9. COTR/Specialist: Name: ____________ Phone: ____________
10. District Office OSH Contact: Name: ____________ Phone: ____________
11. Facility Representative: Name: ____________ Phone: ____________

Section C. Evaluation

The purpose of this section is for the District Office Manager or designee to determine if there is a potential safety and health impact to NAS operations from the construction and/or specific maintenance project based on the information provided in Section B. The sections below describing potential impacts to NAS operations are to be completed by the organization managing the construction project or large-scale maintenance task. The District Office Manager or designee must sign and date below. If there is no impact, proceed to Section I.

Is there a potential safety and health hazard that will impact NAS operations?

________ Yes (Checklist to be returned to the organization managing the construction project for completion.)

No

____

Name (typed or printed)

____

Signature

Date

Section D. Facility Procedures

Review site-specific FAA procedures and considerations with the contractor/installer/specialist. For example, discuss when or how during the work, emergency plans will be required and/or used .

Facility Procedures	Reviewed?		Notes
	Yes	N/A	
1. Asbestos Contingency Plan			
2. Hazard Communications (e.g. MSDSs)			
3. Lockout/Tagout			
4. Work Permits (e.g., Asbestos, Lead, Hot Work)			
5. Emergency Plans (e.g., Occupant Emergency Plan)			
6. Impacts to Fire Alarm and Suppression Systems			
7. Confined Space Entry			
8. Work at Heights			
9. Restricted Areas Due to OSH Concerns			
10. First Aid/Bloodborne Pathogens			
11. Other			

NOTE: Think about your work and its potential hazards. Consider sensitive NAS operations and all facility personnel that may be impacted by your work. As an example, construction activities with potential for impacting asbestos materials in or near sensitive operations could result in incidents that may disrupt NAS operations.

Section E. Activity Hazard

Note: Provide further explanation of potential hazards, locations, etc. below and attach additional sheets if necessary.

Potential Hazardous Exposures and/or Activities ***Consider Sensitive NAS Operations*:**	Potential for Exposure/Release/ Incident		Description of Hazard
	Yes	No	
1. Asbestos (e.g., tiles & insulation)			
2. Chemical, Gases, Fumes, Vapors, Mist, Dust, Radiation			
a. Painting/Solvent/Adhesive/Sealant			
b. Grinding/Sanding/Cutting/Welding/Soldering			
c. Indoor Air Quality Control (e.g., biological agents, mold, odors, CO_2)			
3. Storage of Hazardous Materials (e.g., flammables, compressed gas)			
4. Impact on HVAC System			
5. Equipment Removal/Installation			
6. Fire Protection (e.g. blocked egress, fire barrier penetration)			
7. Impact to Integrity of Fire Alarm/Suppression System(s)			
8. Lead Exposure (e.g., lead-based paint)			
9. Electrical Safety			
a. Work on Live Electrical Systems			
b. Temporary Wiring			
10. Noise			
11. Walking/Working Surfaces (e.g., tripping hazards, work at heights)			
12. Work Above Equipment/People			
13. Water Quality/Sanitation			
14. Cranes/Rigging/Hoisting			
15. Lighting			
16. Machinery and Mechanized Equipment (e.g., operator training and certification and equipment certification)			
17. Excavation			
18. Other			

Pre-Construction
Environmental and Occupational Safety and Health Checklist

Section F. Site Safety and Health - Controls

After reviewing the potential hazards in Section E, ensure that measures and controls to address applicable site safety and health risks (e.g., through discussions, available site safety plans, or other applicable documents) have been identified. If a hazard has been identified in Section E, briefly describe the controls to be used.

Note: Provide further explanation of controls below and attach additional sheets if necessary.

Potential Hazardous Exposures and/or Activities	Identified as a hazard in Section E?	Has this been addressed in site safety plan?	Description of Controls
1. Asbestos (e.g. tiles & insulation)			
2. Chemical, Gases, Fumes, Vapors, Mist, Dust, Radiation			
a. Painting/Solvent/Adhesive/Sealant			
b. Grinding/Sanding/Cutting/Welding/Soldering			
c. Indoor Air Quality Control (e.g., biological agents, odors, CO_2)			
3. Storage of Hazardous Materials (e.g., flammables, compressed gas)			
4. Impact on HVAC System			
5. Equipment Removal/Installation			
6. Fire Protection (e.g., blocked egress, fire barrier penetration)			
7. Impact to Integrity of Fire Alarm/Suppression System(s)			
8. Lead Exposure (e.g., lead-based paint)			
9. Electrical Safety			
a. Work on Live Electrical Systems			
b. Temporary Wiring			
10. Noise			
11. Walking/Working Surfaces (e.g., work at heights, tripping hazards)			
12. Work Above Equipment/People			
13. Water Quality/Sanitation			
14. Cranes/Rigging/Hoisting			
15. Lighting			
16. Machinery and Mechanized Equipment (e.g., operator training and certification and equipment certification)			
17. Excavation			
18. Other			

Section G. Site Safety Walk-Through

Time/date of site walk-through with appropriate personnel (e.g., System Support Center Manager, SECM, District Office representative, contractor, COTR).

______________________ ______________________
Time Date

Personnel

______________________ ______________________
Name Organization

______________________ ______________________
Name Organization

______________________ ______________________
Name Organization

Section H. Review Information

The appropriate FAA point of contact and the contractor/installation crew lead/specialist sign below to document discussion of the items on this form.

Completed By: **Date**

1. **Originator (Project Engineer or Resident Engineer):**

______________________________ ______________

2. **Contractor/Installation Crew Lead/Specialist, and company name:**

______________________________ ______________

Reviewed By: **Date**

1. **District Office Manager or Designee:**

______________________________ ______________

Section I. Distribution of Copies

This form must be forwarded to the following:	Name/Routing Symbol
1. District Office Manager	
2. SECM/District Office OSH Professional	
3. Engineering Services EOSH Coordinator	
4. Engineering Services Manager	
5. Engineering Services Project Engineer	
6. Contracting Officer (if contractor resources perform the construction work)	

FAA Fire Alarm System Certificate of Completion

PROTECTED PROPERTY:

ADDRESS: ____

____

____

FAA CONTACT: ____

TELEPHONE: (____) ________________________FAX: (____)______________________________

SYSTEM INSTALLER:

ADDRESS: ____

____

____

REPRESENTATIVE:______________________________NICET CERT.#: ________________

TELEPHONE: (____) ________________________FAX: (____)______________________________

SYSTEM SUPPLIER:

ADDRESS: ____

____

____

REPRESENTATIVE: ____

TELEPHONE: (____) ________________________FAX: (____)______________________________

SERVICE ORGANIZATION:

ADDRESS: ____

____

____

REPRESENTATIVE:______________________________NICET CERT.#: ________________

TELEPHONE: (____) ________________________FAX: (____)______________________________

Location of AS BUILT Drawings: ____

Location of OWNER'S MANUAL: ____

Location of TEST REPORTS: ____

DIRECTION:

FAA Fire Alarm System Certificate of Completion

Parts 1 and 3 through 9 of this Certification shall be completed after the system is installed and the installation wiring has been checked. Part 2 shall be completed after the operational acceptance tests (FAA, Life Safety System Inspection & Test Report) have been completed and approved by the FAA Safety Office. A preliminary copy of this certificate shall be given to the FAA Project Engineer and to the authority having jurisdiction who will witness operational acceptance tests. A final copy with all signatures after completion of final operational acceptance tests shall be delivered to:

FAA Southern Region Headquarters
Life Safety Office, ASO-471
1701 Columbia Ave.
College Park, GA 30337-2754

PART 1. CERTIFICATION OF SYSTEM INSTALLATION

The system was installed and inspected by:

Name & Title:____________________________ Company:_________________________ on ______ and found to comply with the installation requirements of the FAA project drawings, specifications, and the installation requirements of the NFPA Codes and Standards Referenced, to include all associated appendix sections. The Technician or Electrician, who's signature appears below shall initial each of the following designated spaces below. The initials certify that the required documents have been complied with.

NFPA 72 National Fire Alarm Code 2010 Edition

_________ Chapter 10 Fundamentals

__________Chapter 10.18 Documentation

__________Chapter 23 Protected Premises Fire Alarm Systems

__________Chapter 26.4 Proprietary Supervising Station Systems

__________Chapter 26.6 Digital Alarm Communicator Systems

__________Chapter 17 Initiating Devices

__________Chapter 18 Notification Appliances for Fire Alarm Systems

__________Chapter 14 Inspection, Testing and Maintenance

__________Article 760 of NFPA 70 2011 Edition, National Electrical Code

__________Chapter 5 and Chapter 6 of NFPA 90A 2009 Edition, Standard for the Installation of Air Conditioning and Ventilating Systems

__________ Manufacturer's Guidelines Recommendations and Instructions

__________FAA Project Specifications, Drawings, Written Instructions and Change Orders

PART 2. CERTIFICATION OF SYSTEM OPERATION

FAA Fire Alarm System Certificate of Completion

All operational features and functions of this system were inspected and tested by:

Name & Title: ______________________________Company: _______________________ on _____and found to comply with the installation requirements of the FAA project drawings, specifications written instructions, change orders, and the installation requirements of the NFPA Codes and Standards Referenced, to include associated appendix. The system was found to be operating properly in accordance with the requirements of NFPA 72 National Fire Alarm Code, 2010 Edition. The Technician who's signature appears below shall initial each of the following designated spaces below. The initials certify that the required documents have been complied with:

NFPA 72 National Fire Alarm Code 2010 Edition

__________Chapter 10 Fundamentals of Fire Alarm Systems

__________Chapter 23 Protected Premises Fire Alarm Systems

__________Chapter 26.4 Proprietary Supervising Station Systems

__________Chapter 26.6 Digital Alarm Communicator Systems

_________ Chapter 17 Initiating Devices

_________ Chapter 18 Notification Appliances for Fire Alarm Systems

_________ Chapter 14 Inspection. Testing, and Maintenance

_________ Article 760 of NFPA 70 2011 Edition, National Electrical Code

_________ Chapter 5 and Chapter 6 of NFPA 90A 2009 Edition, Standard for the Installation of Air Conditioning and Ventilating Systems

_________ Manufacturer's Guidelines Recommendations and Instructions

_________ FAA Project Specifications, Drawings, Written Instructions and Change Orders

Configuration of Control Panel Jumper(s):
Is the Control Panel equipped with a Jumper that is capable of disabling detection of Ground Fault conditions YES ____ NO______
Provide a description of the location and the position required for detecting system ground faults:

____

____

Is the Control Panel equipped with other field configured Jumpers YES ______ NO ______
Note each Jumper and it's current configuration below:

____

____

____

____

Note: Contractor may provide a panel schematic diagram with highlighted jumpers) configuration(s) noted in lieu of the above.

PART 3. DACT SYSTEM SERVICE

Enter location(s) of off premise monitoring station:

FAA Fire Alarm System Certificate of Completion

Central Station Name: ____

Address: ____

____

____

Central Station Supervisor:

Name: ______________________________ Title: ______________

Account #: __________ Phone: (___) ______________ FAX: (__) ____________

Part 4. ALARM INITIATING DEVICE CIRCUITS

See NFPA 72 Chapter 23.5 Performance of Initiating Device Circuits (IDC):

	Device Qty	Building Location	Class/Style
Crt. # 1			
Crt. #2			
Crt. #3			
Crt. #4			
Crt. #5			
Crt. #6			
Crt. #7			
Crt. #8			
Crt. #9			
Crt. #10			
Crt. # 11			

Types and quantities of alarm/supervisory initiating devices installed. Check type devices installed, indicate circuit # and quantity of devices:

Qty. **Circuit #(s)**

____ Manual Stations ______________________

____ Photo Smoke Detectors ______________________

____ Ion Smoke Detectors ____

____ Fixed Temp Heat Detectors ____

____ R of R Heat Detectors ____

____ Rate Comp. Heat Detectors ____

____ Photo Duct Detectors ____

____ Ion Duct Detectors ____

____ Sprinkler Water Flow Switches ____

____ Sprinkler Tamper Switches ____

____ Sprinkler PIV Switch ____

____ Water System Air Pressure ____

____ Suppression Panel Alarm ____

____ Suppression Panel Trouble ____

____ Suppression Panel Agent Release ____

____ Supplemental Fire Panel Alarm ____

____ Supplemental Fire Panel Trouble ____

____ Beam Detectors (Xmtr/Rcvr Pair) ____

____ Flame Detectors ____

____ Kitchen Hood Extinguishing System ____

____ Security Contact ____

____ Fire Pump ____

____ Engine Generator ____

____ Other ________________________ ____

Part 5. ALARM NOTIFICATION APPLIANCES AND C1RCTUTS

Quantity of Notification Appliance Circuits (NAC) connected to system and type of Evacuation Signal:

1 /_____/_____/_____/_____	5 /_____/_____/_____/_____	9 /_____/_____/_____/_____
2 /_____/_____/_____/_____	6 /_____/_____/_____/_____	10 /_____/_____/_____/_____
3 /_____/_____/_____/_____	7 /_____/_____/_____/_____	11 /_____/_____/_____/_____
4 /_____/_____/_____/_____	8 /_____/_____/_____/_____	12 /_____/_____/_____/_____

Number/Quantity of Devices/Class/Style/Amps or Watts (see Chapter 23.7 NFPA 72).

General Alarm ____ Temporal Code _____ Voice Evac_____ Fire Phone _____ Other_____

Audible Devices:
Note type and list quantities of alarm indicating appliances (Circuit #/Qty)

____ Bells, 6" ____ 10" ____for notification of Sprinkler System flow on NAC # ____/____, ____/____

____ Horns, Electronic___ Vibrating ___ on NAC# ___/___, ___/___, ___/___, ___/___, ___/___

____ Chimes, Electronic __ Mechanical____on NAC # ___/___, ___/___, ___/___, ___/___

____ Mini-Horns on NAC # ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ Other ______________ on NAC # _/___, _/___, _/___, _/___, _/___, _/___

Speakers:

____ .25 Watt Speakers on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ .5 Wan Speakers on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ .75 Watt Speakers on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ 1.0 Watt Speakers on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ 1.5 Watt Speaker on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ 2.0 Watt Speakers on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ ____Watt Speaker on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ tone for Pre-Alert

____ tone for Evacuation

____ tone for All Clear

____ tone for__________________

Strobes:

____ Visual Lights on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ Incandescent Red Lense on NAC# ___/___, ___/___, ___/___, ___/___, ___/___, ___/___

____ Xenon Strobe (ADA) _____ Candela on NAC # ____ ____ Candela on NAC #_____

____ Candela on NAC #_____ , ____ Candela on NAC # _____ , ____ Candela on NAC #_____

Check the appropriate circuit configuration.

__ Audible/Visual Circuits Combined ____ Audible Circuits Separate ___ Visual Circuits Separate

__ Audible Devices turn off upon Alarm Silence Only ___ Visual Devices turn off upon System RESET

Part 6. SIGNALING LINE CIRCUITS AND DEVICES

See NFPA 72 Chapter 23.6 Performance of Signaling Line Circuits (SLC), note Device Quantity, Circuit Capacity and Class (Class A, B, or X) of circuit.

SLC#1 _____/_____ ____ __________
Qty/Capacity Building Location Class

SLC#2 _____/_____ ____ __________
Qty/Capacity Building Location Class

FAA Fire Alarm System Certificate of Completion

SLC#3 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

SLC#4 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

SLC#5 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

SLC#6 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

SLC#7 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

SLC#8 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

SLC#9 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

SLC#10 ______/______ ______________________________ __________
Qty/Capacity Building Location Class

Types and quantities of addressable initiating-'supervisory devices installed . Check type devices installed, indicate circuit # and quantity of devices:

Qty.	Circuit # (s)
______Manual Stations	______________________________
______Photo Smoke Detectors	______________________________
______Ion Smoke Detectors	______________________________
______Fixed Temp Heat Detectors	______________________________
______R of R Heat Detectors	______________________________
______Rate Comp. Heat Detectors	______________________________
______Photo Duct Detectors	______________________________
______Ion Duct Detectors	______________________________
______Sprinkler Water Flow Switches	______________________________
______Sprinkler Tamper Switches	______________________________
______Sprinkler PIV Switch	______________________________
______Water System Air Pressure	______________________________
______Suppression Panel Alarm	______________________________
______Suppression Panel Trouble	______________________________
______Suppression Panel Agent Release	______________________________
______Supplemental Fire Panel Alarm	______________________________
______Supplemental Fire Panel Trouble	______________________________
______Beam Detectors (Xmtr/Rcvr Pair)	______________________________

______Flame Detectors ____

______Kitchen Hood Extinguishing System ____

______Security Contact ____

______Fire Pump ____

______Engine Generator ____

______Other ______________________ ____

Part 7. SYSTEM POWER SUPPLIES

Primary (Main) Power Supply

Nominal Voltage ____________ , _________ Amps

Overcurrent Protection

Type: ________________________________ Amps:________________________________

Location:

____

____

Secondary (Standby) Power Supply:

____ Storage Battery' _____ AH (Amp-Hr Rating) Battery Type: ________________________________

Calculated capacity-to operate system: ____ Hour Standby ______Minutes Alarm

____ Fire Alarm System provided back-up power from Engine-driven generator.

Location of fuel storage: ________________________________ Fuel Tank Capacity:______________

Emergency or Standby System used as backup to Primary Power Supply, instead of using a Secondary Power Supply:

____ Emergency System described in NFPA 70, Article 700.

____ Legally Required Standby System described in NFPA 70, Article 701.

____ Optional Standby System described in NFPA 70, Article 702, which also meets the performance requirements of Article 700 or 701.

PART 8. SYSTEM DEVIATIONS FROM THE REFERENCED STANDARDS:

____ None ____ As Follows (describe fully)

____

____

____

____

____

PART 9. CERTIFICATION SIGNATURES

The individual(s) and/or contractor(s) signatures below, with their signatures, affirm that the Fire Life Safety System(s) noted herein have been installed to an operational condition that meets or exceeds the codes and standards noted. If upon completion of this certification an acceptable level of protection is in question, due to deficiencies noted, then immediate action shall be taken to correct all the deficiencies. A re-certification of the system(s) installation and/or operation(s) shall be required at no added cost to the FAA. Appropriate action shall be taken to insure the safety of the facilities individuals and operations during any system repair(s) and/or service. The FAA Safety Individual at the CAI shall provide the AF Manager with Fire Watch information to insure a continued safe facility operation during the repairs and service. Any costs incurred as a result of providing a fire watch shall be the contractors responsibility and may be deducted from monies due under the contract. This form shall be accompanied with the required "FAA Life Safety System Inspection & Test Report" for completion of a CAI.

System Installation Contractor:

(Signature-Title) (NICET Certification) (Date)

(Organization) (Phone and FAX)

(Print Name and Title of FAA Test Witness) (Phone and FAX)

(AHJ Witness) (Phone and FAX)

System Commission Contractor:

(Signature-Title) (NICET Certification) (Date)

(Organization) (Phone and FAX)

(Print Name and Title of FAA Test Witness) (Phone and FAX)

(AHJ Witness) (Phone and FAX)

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U.S. Department
of Transportation
**Federal Aviation
Administration**

ATLANTA TERMINAL ENGINEERING CENTER

P.O. Box 20636
Atlanta, Georgia 30320-0631

CERTIFICATE OF SUBSTANTIAL COMPLETION (CoSC)

TO: **FEDERAL AVIATION ADMINISTRATION**

DATE OF SUBSTANTIAL COMPLETION: ______________________

PROJECT TITLE: ______________________

CONTRACT NO. ______________________

PROJECT OR SPECIFIED PART SHALL INCLUDE:
____
____
____

LOCATION: ______________________

CONTRACTOR: ______________________

NTP DATE: ______________________

The Work performed under this Contract has been inspected by authorized representatives of the FAA and Contractor and the Project (or specified part of the Project, as indicated above) is hereby declared to be substantially completed on the above date.

DEFINITION OF SUBSTANTIAL COMPLETION
The date of substantial completion of a project or specified area of a project is defined by the Contract Documents, General Conditions

A tentative list of items to be completed or corrected is appended hereto. This list may not be exhaustive, and the failure to include an item on it does not alter the responsibility of the Contractor to complete all the Work in accordance with the Contract Documents.

The Contractor accepts the above Certificate of Substantial Completion and agrees to complete and correct the items on the tentative list within the time indicated.

____
CONTRACTOR (Typed)

____
AUTHORIZED REPRESENTATIVE (Signature) DATE

____
FAA RESIDENT ENGINEER (Typed)

____
FAA RESIDENT ENGINEER (Signature) DATE

OWNER – FEDERAL AVIATION ADMINISTRATION
The applicable FAA AT, SSC, and SMO concurs with Substantial Completion for the purposes of maintenance and operations of the completed Work.

____
FAA AIR TRAFFIC REPRESENTATIVE (Typed)

____
FAA AIR TRAFFIC REPRESENTATIVE (Signature) DATE

____
FAA SSC REPRESENTATIVE (Typed)

____
FAA SSC REPRESENTATIVE (Signature) DATE

____
FAA SMO REPRESENTATIVE (Typed)

____
FAA SMO REPRESENTATIVE (Signature) DATE

____
REMARKS:

Attached: Substantial Completion Acceptance Form (Copy)
Punchlist Dated _________________
Certificate of Occupancy Dated ________________ (As Required)

cc: FAA Contracting Officer
FAA Project Engineer

CERTIFICATE OF SUBSTANTIAL COMPLETION (CoSC) *(Continued)*

CONTRACT NO. ________________

Concurrent with the issuance of this Certificate, the areas of responsibilities are assigned as follows:

SECURITY: ____

MAINTENANCE: ____

OPERATIONS (CLEANING/HOUSEKEEPING): ________________________________

UTILITIES: ____

PROTECTION OF THE WORK: ____

INSURANCE: ____

HEAT: ____

COMPLETE RECORD DOCUMENTS (DATE): ______________________________

COMPLETE O&M MANUALS (DATE): ___________________________________

DATE REQUIRED FOR COMPLETION OF CORRECTIONS TO THOSE ITEMS CONTAINED IN THE ATTACHED PUNCHLIST: ____

U.S. Department
of Transportation

Federal Aviation Administration

ATLANTA TERMINAL ENGINEERING CENTER

P.O. Box 20636
Atlanta, Georgia 30320-0631

SUBSTANTIAL COMPLETION ACCEPTANCE (SCA)

(72 Hours Notice of Inspection is Required)

PROJECT: ____
(Number & Description)

PART I - NOTICE OF INSPECTION:
The Contractor has requested a substantial completion inspection for referenced project and has submitted the attached punchlist. This inspection is scheduled for:

_______________ at ___________
DATE TIME

All parties will meet at ____ at the above date and time. Please ensure authorized representatives from the following are present:

Contractor: ____

FAA Resident Engineer: ____

FAA Air Traffic: ____

FAA SSC: ____

FAA SMO: ____

FAA ASO-470: ____

Others: ____

PART II – SIGNATURES OF ACCEPTANCE OF SUBSTANTIAL COMPLETION:
The following parties concur referenced project, at the above date and time of inspection, is substantially complete contingent upon concurrence of the punchlist.

Contractor: ____

FAA Resident Engineer:____

FAA Air Traffic:____

FAA SSC: ____

FAA ASO-470: ____

Others: ____

SUBSTANTIAL COMPLETION ACCEPTANCE (SCA) *(Continued)*

PROJECT: ____
(Number & Description)

PART III - PUNCHLIST REVIEW/ACCEPTANCE:
The following parties concur the attached punchlist dated ________________________ is a comprehensive punchlist to the best of their knowledge and is the substantial completion punchlist.

Contractor: ____

FAA Resident Engineer:____

FAA Air Traffic:____

FAA SSC: ____

FAA ASO-470: ____

Others: ____

PART IV - FINAL ACCEPTANCE:

The following parties concur <u>all</u> punchlist items for referenced project were completed on _________________________.

Contractor: ____

FAA Resident Engineer:____

FAA Air Traffic:____

FAA SSC: ____

FAA ASO-470: ____

Others: ____

Part IV must be completed prior to processing the Contractor's final Pay Application. **The OAR is to attach proof of FAA/TN DOT final inspections, as required.**

A copy of this form is to be attached to the Certificate of Substantial Completion at the time of issuance with Parts I through III completed.

cc: FAA Contracting Officer
FAA Project Engineer

U.S. Department
of Transportation

**Federal Aviation
Administration**

ATLANTA TERMINAL ENGINEERING CENTER

P.O. Box 20636
Atlanta, Georgia 30320-0631

PARTIAL OCCUPANCY / USE AGREEMENT (POUA)

TO: **FEDERAL AVIATION ADMINISTRATION**

DATE OF PARTIAL OCCUPANCY/USE: ___________________
-
____

PROJECT OR SPECIFIED PART SHALL INCLUDE:

____

____

____

PROJECT TITLE : ________________________________

CONTRACT NO: ________________________________

LOCATION: ________________________________

CONTRACTOR: ________________________________

NTP DATE: ________________________________

The Work performed under this Contract has been inspected by authorized representatives of the FAA and Contractor and the Project (or specified part of the Project, as indicated above) is hereby declared to be acceptable for Partial Occupancy/Use on the above date.

DEFINITION OF PARTIAL OCCUPANCY/USE

The date of Partial Occupancy/Use of a project or specified area of a project is defined by the Contract Documents, General Conditions

A tentative list of items to be completed or corrected is appended hereto. This list may not be exhaustive, and the failure to include an item on it does not alter the responsibility of the Contractor to complete all the Work in accordance with the Contract Documents.

The Contractor accepts the above Partial Occupancy/Use Agreement and agrees to complete and correct the items on the tentative list within the time indicated.

______________________________ ______________________________
CONTRACTOR (Typed) AUTHORIZED REPRESENTATIVE (Signature) DATE

______________________________ ______________________________
FAA RESIDENT ENGINEER (Typed) FAA RESIDENT ENGINEER (Signature) DATE

OWNER – FEDERAL AVIATION ADMINISTRATION

The applicable FAA AT, SSC, and SMO concurs with Partial Occupancy / Use for the purposes of maintenance and operations of the completed Work.

______________________________ ______________________________
FAA AIR TRAFFIC REPRESENTATIVE (Typed) FAA AIR TRAFFIC REPRESENTATIVE (Signature) DATE

______________________________ ______________________________
FAA SSC REPRESENTATIVE (Typed) FAA SSC REPRESENTATIVE (Signature)DATE

______________________________ ______________________________
FAA SMO REPRESENTATIVE (Typed) FAA SMO REPRESENTATIVE (Signature) DATE

REMARKS: ____

Attached: Punchlist Dated __________________
Certificate of Occupancy Dated _________________ (As Required)

cc: FAA Contracting Officer
FAA Project Engineer

PARTIAL OCCUPANCY/USE AGREEMENT (POUA) ***(Continued)***

CONTRACT NO. ________________

Concurrent with the issuance of this Agreement, the areas of responsibilities are assigned as follows:

SECURITY: ____

MAINTENANCE: ____

OPERATIONS(CLEANING/HOUSEKEEPING): ____

UTILITIES: ____

PROTECTION OF THE WORK: ____

INSURANCE: ____

HEAT: ____

COMPLETE RECORD DOCUMENTS (DATE): ____
(Status)

WARRANTY STARTS (DATE): ____

COMPLETE O&M MANUALS (DATE): ____
(Status)

DATE REQUIRED FOR COMPLETION OF CORRECTIONS TO THOSE ITEMS CONTAINED IN THE ATTACHED PUNCHLIST: ______________________

U.S. Department
of Transportation

**Federal Aviation
Administration**

ATLANTA TERMINAL ENGINEERING CENTER

P.O. Box 20636
Atlanta, Georgia 30320-0631

-6505

JOB MEMORANDUM (JM)

JM No.:______________________ Date:_________________ Sheet _____of_____

To: ______________________________________

Project: ____ **(B.P.__________)**

Field inspection has indicated that the following work is not being performed in accordance with the Contract Documents. The Contractor is requested to provide his proposed Contractor Corrective Action (CCA) no later than ___________.

Reference: Sheet No.: ___________ Specification No.: _________________ Other: ____________________
Subject:____
_

Description of Discrepancy:
____
____
____
____
____
____

Resident Engineer____________________________

CONTRACTOR'S CORRECTIVE ACTION (CCA)

CCA No.: __________ Date:________________ _____
To: **FEDERAL AVIATION ADMINISTRATION – RESIDENT ENGINEERING**

The following action has been
taken____ _________
____
____
____
____
____
____
____
____
___

Contractor __________________________________

FAA's
Response:____

____

cc: FAA Contracting Officer, FAA Project Engineer, A/E

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HOT WORK PERMIT
(for welding, cutting, or brazing activities)

THIS FORM MUST BE COMPLETED IN ITS ENTIRETY BY THE RESPONSIBLE PERSON PERFORMING THE HOT WORK, OR THE RESIDENT ENGINEER OVERSEEING THE CONTRACTOR WHO IS PERFORMING THE HOT WORK.

Facility ID and Type: ________________________

Responsible Person: ________________________

Work to be performed: ________________________
____
____

Date: ________________________

Start Time: ___________________________

Finish Time: ___________________________

Building: ______________________________

Room Number, Area or Equipment:
____

Is it possible to perform this work in a welding shop or other type of workshop? Yes No

Complete the checklist below and if any of the tasks have not been completed, please provide, in the comments section the reasons for not completing the tasks and the precautionary measures that will be implemented.

Task	Yes	No	Comments and/or Corrective Measures
Flame or spark-producing equipment to be used has been inspected and found in good repair.			
Fire Alarm systems are operational and will not be taken out of service while welding, cutting, or brazing activities are performed. If necessary, the automatic smoke detectors in the immediate vicinity of the hot work may be temporarily disabled via functions at the fire alarm control panel or otherwise covered, and returned to operational immediately following the smoke producing activities associated with the hot work.			
Sprinklers, where provided, are operational and will not be taken out of service while this work is being done.			
There are no combustible fibers, dusts, vapors, gases or liquids in the area.			
The work will only be performed in the area specified on this permit.			
Surrounding floors have been swept clean and, if combustible, wet down.			
All floor and wall openings within 35 feet of the operations have been tightly covered.			
All combustibles have been relocated at least 35 feet from the operation. If no, then are barriers or guards used to contain the heat, sparks and slag. Protection should include metal guards or flame- proofed curtains, blankets, or covers (not ordinary tarpaulins (tarps)).			

Task	Yes	No	Comments and/or Corrective Measures
A "Fire Watch" will be posted in area of activity, prior to starting welding, cutting, and brazing activity, and will patrol the area, including floors above and below, during any lunch or rest period and for at least one-half hour after the work has been completed to ensure the sparks and slag have not started fires.			
If bystanders and/or fire watch may be exposed to UV or burn hazards they will be appropriately protected with PPE.			
Fire extinguisher available for instant use within 20 ft.			
Cutter/welder is trained in safe operation of equipment and the safe use of the process.			
On-site contractors were advised about flammable material or hazardous conditions of which they may not be aware.			
Welding or cutting on material containers that contain or did contain flammables: Container thoroughly cleaned and ventilated; Any pipe lines or connections to containers disconnected or blanked; and Approved by ROSHM or EOSH Coordinator.			
Personal Protective Equipment (PPE) used: Eye protection Helmets Protective clothing Other (Specify)			
Warning sign posted to warn of hot metal.			
Appropriate ventilation provided.			
When working in confined spaces a permit has been issued as per 1910.146 and local Confined Space Program.			

For specific requirements refer to General Industry Standards 1910.146; 1910.252; .253; .254 and .272 and Construction Standards 1926.803; .350; .352 and .353.

I attest that the above precautions have been taken:

____________________________ ____________________________

Printed Name of Person Responsible for Performing Hot Work | Signature

Approval:

____________________________ ____________________________

Facility Manager - Printed Name | Facility Manager - Signature

NOTE: THIS PERMIT EXPIRES 24 HOURS AFTER THE DESIGNATED "START TIME". IF WORK IS TO CONTINUE ANOTHER PERMIT MUST BE ISSUED.

MAINTAIN THE COMPLETED AND APPROVED PERMITS ON FILE FOR A MINIMUM OF ONE YEAR.

SECTION 01 10 15 - ACRONYMS AND DEFINITIONS

PART 1 - GENERAL

1.1 ACRONYMS AND DEFINITIONS

A. When in the Special Provisions, this specification, drawings, specifications, or documents pertaining to this contract, the following terms are used; the intent and meaning shall be as specified herein.

1. AMS - Acquisition Management System
2. AMSL - Above Mean Sea Level
3. AOA - Air Operations Area
4. ARCHITECT - Architectural Engineering Firm of Record
5. ATCT - Airport Traffic Control Tower
6. CAI - Contractors Acceptance Inspection or Substantial Completion
7. CFM - Contractor-Furnished Material
8. CO - FAA Contracting Officer
9. Contr. - Contractor
10. COR - FAA Contracting Officer Representative (Fulltime Onsite Representative of the FAA and is also referred to as the COTR) Contracting Officer's Technical Representative
11. DESIGNER - Architectural Engineering Firm of Record
12. ENGINEER - Architectural Engineering Firm of Record
13. FAA - Federal Aviation Administration (Owner)
14. GFE - Government-Furnished Equipment
15. GFM - Government-Furnished Material
16. GOVERNMENT – FAA
17. GSO – Greensboro International Airport
18. IAW - In Accordance With
19. MSL - Mean Sea Level
20. NEC - National Electric Code
21. NTP - Notice to Proceed
22. OSHA - Occupational Safety and Health Administration
23. Owner - FAA
24. RE - FAA Contracting Officer Representative (Fulltime Onsite Representative of the FAA and is also referred to as the COR).
25. RWY - Runway
26. Sponsor - Airport Owner or Airport Authority
27. TWY - Taxiway
28. U/L or UL - Underwriters Laboratories

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 01 10 15

SECTION 01 25 00-SUBSTITUTION PROCEDURES

PART 1 – GENERAL

1.1 DEFINITIONS

A. Substitution: Any product or material that is submitted that is not the exact make and model number of the design basis shall be considered a substitution. This includes products that are from the same manufacturer, but are different models. If the design basis is discontinued or obsolete, any product replacement is also considered a substitution. All substitutions shall follow the substitution procedures listed herein.

B. Known Acceptable Source: A manufacturer of a particular product or material that has been utilized successfully on past FAA projects. This is not an indication that a particular manufacturer will meet the requirements of each FAA project, only that they have been found to meet the requirements on past projects.

C. Basis of Design: Well-defined requirements consist of a set of statements that could form the basis of inspection and test acceptance criteria.

1.2 SUBSTITUTION PROCEDURE

A. Submission of request for substitution shall constitute a representation by the Contractor that he:

1. Has investigated the proposed product and determined that it is equal to or better than the specified product. Absence of an explicit comparison of any characteristic of the proposed product to the specified product shall constitute a representation that the proposed product is equal to or better than the specified product with regard to that characteristic.
2. Will provide the same warranty for the proposed product as for the specified product.
3. Will coordinate the installation and make other changes which may be required for the work to be complete in all respects, including:

    a. Redesign.
    b. Additional components and capacity required by other work affected by the change.
    c. Update BIM.

4. Waives all claims for additional costs and time extensions which subsequently may become apparent and which are caused by the change.
5. Will reimburse the Government for additional costs for evaluation of the substitution request, redesign if required, and reapproval by authorities having jurisdiction if required.

B. Substitutions will not be considered when acceptance would require substantial revision of the contract documents.

C. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals without separate written request.

D. Substitution requests will not be considered when submitted directly by subcontractor or supplier.

E. Substitution Request Procedure: Submit written request with complete data substantiating compliance of the proposed product with the requirements of the contract documents.

1. Submit request to the Contracting Officer Representative (COR).

2. Submit 3 copies of each request and accompanying data.

3. Submit all requests on a standard form provided.

4. Only one request for substitution will be considered for each product.

F. Data Required with Substitution Request: Provide at least the following data:

1. Identify product by specification section and paragraph number.

2. Manufacturer's name and address, trade name and model number of product (if applicable), and name of fabricator or supplier (if applicable).

3. Complete product data.

4. A list of other projects on which the proposed product has been used, with project name, and the design professional's name.

5. An itemized comparison of the proposed product to the specified product.

6. Net amount of change to the contract sum.

7. List of maintenance services and replacement materials available.

8. Statement of the effect of the substitution on the construction schedule.

9. Description of changes that will be required in other work or products if the substitute product is approved.

G. The COR will determine acceptability of the proposed substitution.

H. When the proposed substitution is not accepted, provide the product (or one of the products, as the case may be) specified.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

NOT USED

END OF SECTION 01 25 00

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PRODUCT SUBSTITUTION REQUEST FORM

Note: This form to be used by General Contractor only. Requests by others will be returned with no response.

Project:
Location:____

Government:____

Date: ____

We hereby submit for your consideration the following substitution instead of the item specified or shown on the Drawings:

Section Number: Paragraph Specified item
____

Proposed Substitution:
____

____

Attach complete product data, drawings and descriptions of products, with fabrication and installation details. Provide laboratory tests if applicable.

Provide sample, if applicable. Indicate if sample will be provided under separate cover.

Include complete information on changes to Drawings and/or Specifications that proposed substitution will require for its proper installation.

Fill in blanks below: *(Include attachments if space is insufficient. Failure to provide information will void submittal)*

A. Reason(s) for proposed substitution: *(check all that apply)*

_____1. Request is equivalent to product/material/assembly specified. *(Note: Attach technical documentation)*

_____ 2. Specified product or method cannot be provided within the Contract time. *(Note: This request will not be considered if the product or method cannot be provided as a result of the Contractor's failure to pursue the Work promptly, or to coordinate the various activities properly, of if the Contractor fails to place timely orders)*

_____ 3. Specified product or method cannot receive necessary approval by authority having jurisdiction, and Contractor certifies that the requested substitution can be approved. *(Note: Attach approval documentation)*

_____ 4. A substantial advantage is offered the Government, in terms of cost, time, energy conservation or other considerations of merit, after deducting redesign and evaluation costs of other work by the Government or separate contractors and similar considerations.

_____ 5. Specified product or method cannot be provided in a manner which is compatible with other materials of the Work, and the Contractor certifies that the substitution will overcome the incompatibility.
_____ 6. Specified product cannot be properly coordinated with other materials in the Work, and the Contractor certifies that the proposed substitution can be properly coordinated.
_____ 7. Specified product or method cannot receive a warranty as required by Contract Documents, and Contractor certifies that the proposed substitution can receive required warranty.

B. B. Does the substitution affect dimensions or details shown on Drawings:
_____ No

_____ Yes *(Note: Attach marked up prints of drawings showing changes required)*

C. C. What effect does the substitution have on other trades?

____

____

D. D. Compare significant qualities of proposed substitution with those of work or product originally specified or shown on drawings. Include elements such as size, weight, durability, performance, visual effect, etc.

____

____

E. E. Coordinate information. Include all changes required in other elements of the work in order to accommodate the substitution, including work performed by Government or separate contractors.

____

____

F. F. State effect substitution will have on the work schedule in comparison to the schedule which would prevail without the proposed substitution. State the effect of the proposed substitution on Contract Time.

____

____

G. G. Provide complete cost information, including a proposal of any net change in the Contract Amount.

____

____

H. H. Manufacturer’s warranties of the proposed substitution and specified items are:
_____ Same

_____ Different *(Note: Explain on attachment)*

The undersigned Contractor certifies its opinion that, after thorough evaluation, the proposed substitution will result in work that in every significant respect will be equivalent to or superior to the work required by the original Contract Documents and that it will perform adequately in the application indicated.
Rights to additional payment or time because of failure of the substitution to perform adequately are hereby waived.

The undersigned hereby agrees to pay in full for any changes to design, including detailing and engineering costs caused by the requested substitution.

Submitted by: *(Note: Submittal void and will be discarded if unsigned or if signed by entity other than Contractor)*

Signature: ____
(Contractor's authorized representative)

____
(Title)

Firm Name: ____

Date: ____

For use by Contracting Officer Representative:

_____ Accepted **_____ Accepted as Noted**

_____ Not Accepted **_____ Received too late**

By: ____________________________________ Date: ____________________________________
(Contracting Officer Representative)

By: ____________________________________ Date: ____________________________________
(Contracting Officer Representative)

Remarks:

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SECTION 01 31 00 - PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:

1. General project coordination procedures.
2. Administrative and supervisory personnel.
3. Coordination drawings.
4. Requests for Information (RFIs).
5. Project Web site.
6. Project meetings.

1.2 DEFINITIONS

A. RFI: Request for Information from COR, Designer, or Contractor seeking information from each other during construction.

1.3 COORDINATION

A. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations, included in different Sections that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.
4. Per Section 01 31 00 – 1.5-E, provide a qualified fulltime on-site Coordinating Engineer to coordinate project requirements and interface with the COR.

B. Coordination Drawings, General: Prepare coordination drawings in accordance with Section 01 40 10 and requirements in individual Sections.

C. Project Coordination Schedule: The General Contractor will prepare and maintain a mutually agreed upon spatial coordination schedule with coordination drawing submittal milestones that meet the overall project construction schedule. Coordination drawing development, coordination submittal drawing submission and review by the COR, fabrication duration, and delivery lead times will be included to support the project construction schedule.

D. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.

1. Prepare similar memoranda for COR and separate contractors if coordination of their Work is required.

E. Coordination Meetings: The Coordinating Engineer shall host regular weekly (or more frequent) coordination meetings in accordance with Section 01 31 00 – 1.8-F. Attendance is mandatory by all Team members to maintain the coordination and construction schedules.

F. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's construction schedule.
2. Preparation of the schedule of values.
3. Installation and removal of temporary facilities and controls.
4. Delivery and processing of submittals.
5. Progress meetings.
6. Pre-installation conferences.
7. Project closeout activities.
8. Startup and adjustment of systems.
9. Project closeout activities.

G. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste.

1. Salvage materials and equipment involved in performance of, but not actually incorporated into, the Work. Refer to other Sections for disposition of salvaged materials that are designated as FAA's property.

1.4 KEY PERSONNEL

A. Key Personnel Names: Within 14 calendar days of Notice to Proceed, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home, office, and cellular telephone numbers and email addresses. Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.

1. Post copies of list in project meeting room, in temporary field office, and by each temporary telephone. Keep list current at all times.

1.5 CONTRACTOR PERSONNEL REQUIREMENTS

A. Project Manager with a minimum of a Bachelor of Science (BS) degree in Civil, Mechanical, or Electrical Engineering from an accredited institution of higher learning, or a technical degree, and ten (10) years of experience with coordinating subcontractors on projects with complex mechanical, electrical, and control systems in the heavy construction industry.

B. Project Superintendent with a minimum of ten (10) years of experience in coordinating mechanical, electrical, and control subcontractors in heavy construction industry.

C. Project Scheduler with minimum of five (5) years of experience in coordinating large complex construction projects involving multiple construction disciplines with a typical project length of 18 or more months.

D. Coordinating Engineer: The contractor's project staff shall include a full-time person (from NTP through Substantial Completion) having the responsibility of coordinating all work between trades. This individual shall submit evidence of previous experience in coordinating these areas of work on projects of similar scale and complexity.

1. Responsibilities shall include, but are not limited to the following:

a. Facilitating coordination meetings between architectural/interior design, furniture/ fixtures/equipment, structural, mechanical, electrical/ telecommunications, and fire protection sub-contractors.
b. Reviewing all trades shop drawings following the approval of the coordinated submittals.
c. Directing adjustments in the Work that shall be required to comply with the Contract Documents.

E. Environmental Manager with a minimum of eight (8) years construction experience on projects of similar size and scope with environmental procedures similar to those on this project. On-site party designation responsible for overseeing the Contractor's conformance to meet environmental goals for the project and implementing procedures for environmental protection and Guiding Principles for Federal Leadership in High Performance and Sustainable buildings. This is not a collateral duty for the superintendent or QA/QC lead.

1. Responsibilities shall include:

a. Compliance with applicable Federal, State, and local environmental regulations, including maintaining required documentation.
b. Implementation of the Waste Management Plan.
c. Implementation of the Environmental Protection Plan.
d. Training for Contractor personnel in accordance with their position requirements.
e. Monitoring and documentation of environmental procedures.
f. Perform environmental project quality control
g. Contractor's Environmental Training Program: Contractor shall provide environmental training for workers performing work on the project site. Training shall include the following:

1) Overview of environmental issues related to the building industry.
2) Overview of environmental issues related to the Project.
3) Review of site specific procedures and management plans:

a. Waste Management
b. Indoor Air Quality (IAQ) Management

c. Noise & Acoustics Management
d. Environmental Management

1.6 CONSTRUCTION PROGRESS PHOTOGRAPHS

A. Provide construction photographs of the project on a once-per-month basis. In addition:

1. Provide a minimum of four aerial views adequate to cover all sides of the ATCT. Emphasis should be given to photographing on a clear and non-hazy day, when the sun is well above the horizon (whenever scheduling permits). Aerials are typically taken from either a fixed-wing aircraft or helicopter (at the photographer's option).
2. Final Completion Photographs: After date of Substantial Completion and all temporary structures have been removed provide a final set of aerial views.

1.7 REQUESTS FOR INFORMATION (RFIs)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified to the COR.

1. COR will return RFIs submitted by other entities controlled by Contractor with no response.
2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
3. Project number.
4. Date.
5. Name of Contractor.
6. Name of COR.
7. RFI number, numbered sequentially.
8. RFI subject.
9. Specification Section number and title and related paragraphs, as appropriate.
10. Drawing number and detail references, as appropriate.
11. Field dimensions and conditions, as appropriate.
12. Contractor's suggested resolution. If Contractor's solution(s) impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
13. Contractor's signature.
14. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

    a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. RFI Forms: Refer Section 01 10 12 Construction Administration Forms.

D. COR's Action: COR will review each RFI, determine action required, and respond. Allow seven (7) calendar days for COR's response for each RFI. RFIs received by COR after 1:00 P.M. local time will be considered as received the following working day.

1. The following RFIs will be returned without action:

a. Requests for approval of submittals.
b. Requests for approval of substitutions.
c. Requests for coordination information already indicated in the Contract Documents.
d. Requests for adjustments in the Contract Time or the Contract Sum.
e. Requests for interpretation of Designer's actions on submittals.
f. Incomplete RFIs or inaccurately prepared RFIs.

2. COR's action may include a request for additional information, in which case COR's time for response will date from time of receipt of additional information.
3. COR's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Division 01 Section "Contract Modification Procedures."

a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify COR in writing within four (4) calendar days of receipt of the RFI response.

E. On receipt of COR's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify COR within seven (7) calendar days if Contractor disagrees with response.

F. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log weekly. Use CSI Log Form 13.2B. Include the following:

1. Project name.
4. Name and address of Contractor.
5. RFI number including RFIs that were dropped and not submitted.
6. RFI description.
7. Date the RFI was submitted.
8. Date COR's response was received.
9. Identification of related Minor Change in the Work, Construction Change Directive, and Proposal Request, as appropriate.
10. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.

1.8 PROJECT MEETINGS

A. General: Schedule and conduct meetings and conferences at Project site, unless otherwise indicated.

1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify COR of scheduled meeting dates and times.

2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.
3. Minutes: Contractor shall record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including COR, within three days of the meeting.

B. Preconstruction Conference: COR will schedule and conduct a preconstruction conference before starting construction, at a time convenient to the government and the contractor, but no later than 15 days after execution of the Agreement.

1. Conduct the conference to review responsibilities and personnel assignments.
2. Attendees: Authorized representatives of COR's; project manager, project superintendent; project scheduler, coordinating engineer; environmental manager; major subcontractors; suppliers; and other concerned parties shall attend the conference. Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
3. Agenda: Discuss items of significance that could affect progress, including the following:

a. Tentative construction schedule.
b. Phasing/sequencing.
c. Permits
d. Critical work sequencing and long-lead items.
e. Designation of key personnel and their duties.
f. Lines of communications.
g. Procedures for processing field decisions and Change Orders.
h. Procedures for RFIs.
i. Procedures for testing and inspecting.
j. Procedures for processing Applications for Payment.
k. Distribution of the Contract Documents.
l. Submittal procedures.
m. Sustainable design requirements.
n. Preparation of record documents.
o. Use of the premises.
p. Work restrictions.
q. Working hours.
r. FAA's occupancy requirements.
s. Responsibility for temporary facilities and controls.
t. Procedures for moisture and mold control.
u. Procedures for disruptions and shutdowns.
v. Construction waste management and recycling.
w. Parking availability.
x. Office, work, and storage areas.
y. Equipment deliveries and priorities.
z. First aid.
aa. Security.
bb. Progress cleaning.
cc. Environmental requirements and procedures, including but not limited to:

1) Erosion and Sediment control;
2) Solid Waste Management Plan;
3) IAQ Management Plan;

4) Procedures for noise and acoustics management;
5) Environmental Management Plan;
6) Commissioning.

4. Minutes: Contractor shall record and distribute meeting minutes.

C. Pre-installation Conferences: Conduct a preinstallation conference at Project site before each construction activity that requires coordination with other construction.

1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise COR of scheduled meeting dates.
2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following:

a. Contract Documents.
b. Options.
c. Related RFIs.
d. Related Change Orders.
e. Purchases.
f. Deliveries.
g. Submittals.
h. Review of mockups.
i. Possible conflicts.
j. Compatibility problems.
k. Time schedules.
l. Weather limitations.
m. Manufacturer's written recommendations.
n. Warranty requirements.
o. Compatibility of materials.
p. Acceptability of substrates.
q. Temporary facilities and controls.
r. Space and access limitations.
s. Regulations of authorities having jurisdiction.
t. Testing and inspecting requirements.
u. Installation procedures.
v. Coordination with other work.
w. Required performance results.
x. Protection of adjacent work.
y. Protection of construction and personnel.

3. Contractor shall record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.
4. Reporting: Distribute minutes of the meeting to each party present and to other parties requiring information.
5. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date.

D. Project Closeout Conference: Schedule and conduct a Project closeout conference, at a time convenient to the COR, but no later than 60 days prior to the scheduled date of Substantial Completion.

1. Conduct the conference to review requirements and responsibilities related to Project closeout.
2. Attendees: Authorized representatives of COR; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the meeting. Participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
3. Agenda: Discuss items of significance that could affect or delay Project closeout, including the following:

    a. Preparation of record documents.
    b. Procedures required prior to inspection for Substantial Completion and for final inspection for acceptance.
    c. Submittal of written warranties.
    d. Requirements for preparing sustainable design documentation.
    e. Requirements for preparing operations and maintenance data.
    f. Requirements for demonstration and training.
    g. Preparation of Contractor's punch list.
    h. Procedures for processing Applications for Payment at Substantial Completion and for final payment.
    i. Submittal procedures.
    j. Coordination of separate contracts.
    k. FAA's partial occupancy requirements.
    l. Installation of FAA's furniture, fixtures, and equipment.
    m. Responsibility for removing temporary facilities and controls.

4. Minutes: Contractor shall record and distribute meeting minutes.

E. Progress Meetings: Construction manager shall conduct progress meetings at weekly intervals.

1. Coordinate dates of meetings with preparation of payment requests.
2. Attendees: In addition to representatives of the COR, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
3. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

    a. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

        1) Review schedule for next period.

b. Review present and future needs of each entity present, including the following:

1) Interface requirements.
2) Sequence of operations.
3) Status of submittals.
4) Deliveries.
5) Off-site fabrication.
6) Access.
7) Site utilization.
8) Temporary facilities and controls.
9) Progress cleaning.
10) Quality and work standards.
11) Status of correction of deficient items.
12) Field observations.
13) Status of RFIs.
14) Status of proposal requests.
15) Pending changes.
16) Status of Change Orders.
17) Pending claims and disputes.
18) Documentation of information for payment requests.
19) Status of environmental plans.
20) Commissioning efforts.

4. Minutes: Contractor shall record and distribute the meeting minutes to each party present and to parties requiring information.

a. Schedule Updating: Revise Contractor's construction schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

F. Coordination Meetings: Conduct project coordination meetings at weekly intervals. Project coordination meetings are in addition to specific meetings held for other purposes, such as progress meetings and preinstallation conferences.

1. Attendees: In addition to COR, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meetings shall be familiar with Project and authorized to conclude matters relating to the Work.
2. Agenda: Review and correct or approve minutes of the previous coordination meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

a. Combined Contractor's Construction Schedule: Review progress since the last coordination meeting. Determine whether each contract is on time, ahead of schedule, or behind schedule, in relation to combined Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

b. Schedule Updating: Revise combined Contractor's construction schedule after each coordination meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with report of each meeting.

c. Review present and future needs of each contractor present, including the following:

1) Revise list below to suit Project.
2) Interface requirements.
3) Sequence of operations.
4) Status of submittals.
5) Deliveries.
6) Off-site fabrication.
7) Access.
8) Site utilization.
9) Temporary facilities and controls.
10) Work hours.
11) Hazards and risks.
12) Progress cleaning.
13) Quality and work standards.
14) Change Orders.

3. Reporting: Contractor shall record meeting results and distribute copies to everyone in attendance and to others affected by decisions or actions resulting from each meeting.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 31 00

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SECTION 01 32 00 - CONTRACTOR-PREPARED NETWORK ANALYSIS SYSTEM

PART 1 - GENERAL

1.1 CONTRACTOR-PREPARED NETWORK ANALYSIS SYSTEM

A. General: The progress chart to be prepared by the Contractor pursuant shall consist of a network analysis system (NAS) as described below in Section #2 titled "NAS Content". In preparing this system, the scheduling of construction is the responsibility of the Contractor. The requirement for the system is included to assure adequate planning and execution of the work and to assist the Contracting Officer in appraising the reasonableness of the proposed schedule and evaluating progress of work.

1. NAS Reference Guide: The United States Army Corps of Engineers' pamphlet EP 415-1-4 (31AUG86), "Network Analysis Systems Guide," is a primer on the subject and provides a basic introduction to network scheduling. Single copies of the guide are available to bona fide bidders on request. The system proposed for use will be accepted subject to the approval of the Contracting Officer.
2. NAS Content: The system shall consist of diagrams and accompanying mathematical analyses. The diagrams shall show elements of the project in detail and the entire project in summary.

a. Diagrams: Diagrams shall show the order and the interdependence of activities and the sequence in which the work is to be accomplished as planned by the Contractor. The basic concept of a network analysis diagram will be followed to show how the start of a given activity is dependent on the completion of preceding activities and its completion restricts the start of following activities.
b. NAS Items: Network activities shown on a detailed or subnetwork diagram shall include, in addition to construction activities, etc., submittal, review and approval of samples of materials and shop drawings, the procurement of critical materials and equipment, fabrication of special material and equipment and their installation and testing. Contract-required milestone dates for completion of all or parts of the work will be shown. All activities of the Government and others that affect progress, including, but not limited to, the requirements in TECHNICAL SPECIFICATIONS, Paragraph GOVERNMENT-FURNISHED MATERIAL (GFM), shall be shown. The detail of information shall be such that duration times of activities will range from three (3) to thirty (30) days with not over two percent (2%) of the activities exceeding these limits. Activities involving the procurement, delivery and installation of major items of equipment shall be separated into a procurement and delivery activity and into an installation activity. The activities related to separate buildings and features shall be separately identifiable by coding or use of subnetworks or both.

1) NAS Approval: The selection of activities shall be subject to the Contracting Officer's approval. Detailed networks, when summary networks are also furnished, need not be time scaled but shall be drafted to show a continuous flow from left to right with no arrows from right to left;

the critical path shall be clearly designated. The following information shall be shown on the diagrams for each activity: preceding and following event numbers, description of the activity, cost and activity duration in calendar days. In calculating activity durations, Saturdays, Sundays, holidays, and normal inclement weather shall be considered.

c. Summary Network: If the project is of such size that the entire network cannot be readily shown on a single sheet, a summary network diagram shall be provided. The summary network diagram shall consist of a minimum of 50 activities and a maximum of 150 activities, and shall be based on and supported by detailed diagrams. Related activities shall be grouped on the network. The critical path shall be plotted generally along the center of the sheet with increasing float placed towards the top or bottom. The summary network shall be time scaled using units of approximately one-half-inch equals one week or other suitable scale approved by the Contracting Officer. Weekends and holidays shall be shown. Where slack exists, the activities shall be shown at the time when they are scheduled to be accomplished.

d. NAS Calculation: The mathematical analysis of the network diagram shall include a tabulation of each activity shown on the detailed network diagrams. The following information will be furnished as a minimum for each activity:

1) Preceding and following event numbers (numbers shall be selected and assigned so as to permit identification of the activities with bid items)
2) Activity description (identify the work to be performed)
3) Estimated duration of activities (the best estimate available at time of computation in calendar days);
4) Earliest start date (by calendar date)
5) Earliest finish date (by calendar date)
6) Actual start date (by calendar date)
7) Actual finish date (by calendar date)
8) Latest start date (by calendar date)
9) Latest finish date (by calendar date)
10) Slack or float (in calendar days)
11) Monetary value of activity
12) Responsibility for activity (Contractor, subcontractors, suppliers, Government, etc.)
13) Percentage of activity completed
14) Contractor's earnings based on portion of activity completed
15) Bid item of which activity is a part

e. NAS Capability: The program or means used in making the mathematical computation shall be capable of compiling the total value of completed and partially completed activities and subtotals from separate buildings or features listed in paragraph A.2.b. The program shall be capable of accepting revised completion dates as modified by approved time adjustments and recomputing all tabulation dates and float accordingly.

f. Additional NAS Features: In addition to the tabulation of activities, the computation shall include the following data:

1) Identification of activities which are planned to be performed by use of overtime or multi-shifts to be worked including Saturdays, Sundays, and holidays.
2) A description of the major items of construction equipment planned for operations of the project. The description shall include the type, number of units and unit capacities. A schedule showing proposed time equipment will be on the job keyed to activities on which equipment will be used shall be provided.
3) The analysis shall list the activities in sorts or groups as follows:

    a) By the preceding event number from lowest to highest and then in the order of the following event number.
    b) By the amount of slack, then in order of preceding event number.
    c) By responsibility in order of earliest allowable start dates.
    d) In order of latest allowable start dates, then in order of preceding event numbers, and then in order of succeeding event numbers.

3. Submission and Approval: Submission and approval of the system shall be as follows:

    a. A preliminary network defining the Contractor's planned operations during the first seventy-five (75) calendar days after notice to proceed shall be submitted within ten (10) days after notice to proceed. The Contractor's general approach for the balance of the project shall be indicated. Cost of activities expected to be completed or partially completed before submission and approval of the whole schedule shall be included.
    b. The complete network analysis consisting of the detailed network mathematical analysis and network diagrams shall be submitted within forty (40) calendar days after receipt of notice to proceed. A graph shall be included showing cumulative placement in dollar value over the life of the project. The vertical scale will show scheduled percent completion based on dollar value, from 0% to 100%. Show dollar amounts associated with various percentages, including 100%. The horizontal scale will be at a time scale showing the calendar months of the project. Three curves will be plotted on the same graph; the first will be percent completion based on early finish dates; the second will be percent completion based on late finish dates; the third will be a curve showing the average between percentages of early finish and late finish values.

4. NAS Review and Evaluation. - The Contractor shall participate in a review and evaluation of the proposed network diagrams and analysis by the Contracting Officer. Any revisions necessary as a result of this review shall be resubmitted for approval of the Contracting Officer within ten (10) calendar days after the conference. The approved schedule shall then be the schedule to be used by the Contractor for planning, organizing and directing the work and for reporting progress. If the Contractor thereafter desires to make changes in his method of operating and scheduling he shall notify the Contracting Officer in writing stating the reasons for the change. If the Contracting Officer considers these changes to be of a major nature he may require the Contractor to revise and submit for approval, without additional cost to the Government, all or the affected portion of the detailed diagrams and mathematical analysis and the summary diagram to show the

effect on the entire project. A change will be considered to be of a major nature if the time estimated to be required or actually used for an activity or the logic of sequence of activities is varied from the original plan to a degree that there is a reasonable doubt as to the effect on the Contract completion date or dates. Changes which affect activities with adequate slack time shall be considered as minor changes, except that an accumulation of minor changes may be considered a major change when their cumulative effect might affect the Contract completion date.

5. Contractor Monthly Report: The Contractor shall submit at monthly intervals a report of the actual construction progress by updating the mathematical analyses. A copy of the entire updated schedule shall also be submitted monthly on a 700+ MB compact disk or other approved portable electronic media and uploaded to FAA's KSN website. Media shall be compatible with the system previously approved. Entering or updating information into the mathematical analysis will be subject to the approval of the Contracting Officer. Revisions causing changes in the detailed network shall be noted on the summary network, or a revised issue of affected portions of the detailed network furnished. The summary network shall be revised as necessary for the sake of clarity.

   a. Report Content: The report shall show the activities or portions of activities completed during the reporting period and their total value as basis for the Contractor's periodic request for payment. Payment made pursuant to the Contract Clause entitled "Payments Under Fixed-Price Construction Contracts" will be based on the total value of such activities completed or partially completed after verification by the Contracting Officer. The report shall state the percentage of the work actually completed and scheduled as of the report date and the progress along the critical path in terms of days ahead or behind the allowable dates. If the project is behind schedule, progress along other paths with negative slack shall also be reported.
   b. Narrative Report: The Contractor shall also submit a narrative report with the updated analysis which shall include but not be limited to a description of the problem areas, current and anticipated, delaying factors and their impact, and an explanation of corrective actions taken or proposed. Identification of problem areas within this report will not be acknowledged to constitute proper notification of any intended or potential claim. Any request for additional reimbursement must be made the subject of separate correspondence. The report shall include an updated version of the graph specified; actual completion percentages shall be shown, together with revisions to the scheduled completion dates.

6. Sheet size of diagrams shall be 22 by 34 inches. Each updated copy shall show a date of the latest revision.
7. Initial submittal and complete revisions shall be submitted in four (4) copies (including one reproducible).
8. Monthly reports and schedule analysis (printout) shall be submitted in three (3) copies
9. Changes affecting the project schedule: When changes affecting the network or work schedule are necessary, the Contractor will submit revisions to the network for all activities affected in response to the request for proposal. All changes shall be shown as separate activities on the network. The Contractor will prepare a Time Impact Analysis, which will be based on the current schedule data, job conditions, and progress achieved at the time the change is issued or the delay occurs. The Contractor will submit a separate Time Impact Analysis sheet, which will include proper identification,

references, adequate description, details of evaluation including network calculation, and conclusion that establish the Contractor's position on the effect of the change. If settlement has not been reached on the price and/or time of the proposed change order prior to Notice to Proceed, or the Contractor has failed to submit revisions to the network logic, the Contracting Officer may furnish to the Contractor the suggested logic and/or duration time changes to be entered into the network and used in all subsequent updating reports until such time that the proposed change order has been settled or until the logic and duration are superseded. Inclusions in the network and use of revised logic and/or duration time estimates for updating, whether furnished by the Contractor or by the Contracting Officer, shall not be construed as extensions of time to the dates required in the Contract. These changes are for the purpose of keeping the schedule up to date to reflect the work to be accomplished and to include the best time estimates for work yet to be done. If it becomes necessary for the Contracting Officer to furnish the suggested logic and/or duration time revisions because of the Contractor's failure to furnish acceptable data on time, and if the Contractor has any objections to the data furnished by the Contracting Officer, he shall advise the Contracting Officer promptly, in writing, of such objections fully supported by his own counterplan; however, he will continue to use the revisions suggested by the Contracting Officer for all updating until such time as the Contracting Officer may approve alternate data. If the Contractor fails to submit, in writing, his objections to the revisions along with supporting data and counterplan within twenty (20) days after the date such suggested revisions were furnished by the Contracting Officer, the Contractor will be deemed to have concurred in the Contracting Officer's suggested logic/duration time changes, which changes then will be the basis for equitable adjustment of the time for performance of the work

10. Float or Slack Time: Float or slack is defined as the amount of time between the early start date and the late start date, or the early finish date and the late finish date, of any of the activities in the NAS schedule. Float or slack is not time for the exclusive use of or benefit of either the Government or the Contractor. Extensions of time for performance required under the Contract Clauses entitled "CHANGES," "DIFFERING SITE CONDITIONS," "DEFAULT," or "SUSPENSION OF WORK" will be granted only to the extent that the equitable time adjustments for the activity or activities affected exceed the total float or slack along the channels involved at the time Notice to Proceed was issued for the change.

11. Contract Progress Monitoring: The Contractor shall provide the Government with the means to independently obtain and process information from the network analysis data. This capability shall be accomplished as follows:

    a. Contractor Furnished Computer Hardware and Software: Contractor shall acquire commercially available NAS software and install an original version of the software on the COR's computer. The NAS software installed on the COR's computer shall match the software that will be used by the Contractor and shall be fully compatible with the COR's computer hardware and that will process the network data provided by the Contractor with no further computer translation. The Contractor shall initially install the program on the one COR Office microcomputer and shall maintain the software throughout the contract period. The Contractor shall provide all of the software updates that are incorporated into the Contractor's program. The Contractor shall also provide adequate training to the COR Office staff on the use of the furnished software. The software shall remain the property of the Contractor but shall be in the possession of and for the exclusive use by the Government during the contract period. The Contractor may repossess the software after final payment is made on the contract.

12. Additional Reporting: The Contractor shall additionally provide monthly progress information including revised logic, actual activity start dates, actual activity finish dates, and revised activity durations on 700+ MB compact disks, or other approved electronic media. This information, either without further computer translation or with Contractor-provided computer translation, shall be capable of being processed with the hardware and software being used in the Contracting Officer's Representative Office for network analysis system processing.
13. Submission of Contractor Monthly Report shall be required for periodic progress payment.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUSTION

NOT USED

END OF SECTION 01 32 00

SECTION 01 32 00.20 - CONTRACTOR-PREPARED CONSTRUCTION SCHEDULE

PART 1 - GENERAL

1.1 CONTRACTOR-PREPARED CONSTRUCTION SCHEDULE

A. Progress Chart - The Contractor shall prepare a detailed construction schedule for the project. The schedule shall be coordinated with the Contracting Officer's Representative (COR) and include all milestone activities. The scheduling of construction is the responsibility of the Contractor and Contractor management personnel shall actively participate in its development. The requirement for the schedule is included to assure adequate planning and execution of the work and to assist the Contracting Officer (CO) in evaluating progress of work. Submit the Construction Schedule to the CO within ten (10) calendar days after contract award.

Format - The construction schedule shall consist of a diagram or a bar chart showing the start and the end dates of construction as well as the major items to be constructed, what work is occurring, length of time anticipated for the activity and the flow of construction.

Diagram(s) shall show the order and interdependence of activities and the sequence in which the diagram will be followed to show how the start of a given activity is dependent on the completion of preceding activities and its completion restricts the start of following activities.

Diagram activities shall include, in addition to construction activities, the submittal, review and approval of samples of materials and shop drawings, the procurement of critical materials and equipment, fabrication of special materials and equipment and their installation and testing. All activities of the Government and others that affect progress, and contract required dates for completion of all parts of the work shall also be shown.

The construction schedule consists of a minimum of 20 activities. The selection of activities shall be subject to the Contracting officer's approval.

B. Monthly reports.- The Contractor shall submit, as part of the monthly request for payment, three (3) hard copies of the following items

a. An updated construction schedule showing the actual construction progress and its current status.

This information is necessary for the FAA to know the exact cost of the above referenced assets in order to capitalize the assets at the end of the project.

The reports shall show the activities or portions of activities completed during the reporting period and their total value as basis for the Contractor's periodic request for payment. Payment made will be based on the total value of such activities completed or partially completed after verification by the Contracting Officer. The report will state the percentage of the work completed and scheduled as of the report date and the progress along the critical path in terms of days ahead or behind the allowable dates. If the project is behind schedule, progress along other paths with negative slack shall also be reported. The Contractor shall include but not be limited to a description of the problem areas, current and anticipated, delaying factors and their impact, and an explanation of corrective actions taken or proposed.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 01 32 00.20

SECTION 01 33 00 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Submittals listed or specified in this Contract shall conform to the provisions of this section, unless explicitly stated otherwise.

1.2 REFERENCES

NOT USED

1.3 DEFINITIONS

A. Submittal Definition: Shop drawings, product data, samples, administrative and closeout submittals, and additional data presented for review and approval. Contract clauses referring to material, workmanship specifications and drawings for construction shall apply to all submittals.

B. Types of Submittals

1. Shop Drawings. As used in this Section, drawings, schedules, diagrams, and other data prepared specifically for this contract, by the Contractor or through the Contractor by way of a subcontractor, manufacturer, supplier, distributor, or other lower tier contractor, to illustrate a portion of the work.
2. Product Data. Preprinted material such as illustrations, standard schedules, performance charts, instructions, brochures, diagrams, manufacturer's descriptive literature, catalog data, and other data to illustrate a portion of the work, but not prepared exclusively for this Contract. Information such as mix design, material characteristics, and similar data is included herein.
3. Samples. Physical examples of products, materials, equipment, assemblies, or workmanship, physically identical to a portion of the work, illustrating a portion of the work or establishing standards for evaluating the appearance of the finished work or both.
4. Administrative and Closeout Submittals. Submittals of data for which reviews and approval will be to ensure that the administrative requirements of the project are adequately met but not to ensure directly that the work is in accordance with the design concept and in compliance with the contract documents.

C. Approving Authority: Contracting Officer's Representative (COR).

D. Work: As used in this Section, the construction required by the contract documents, including labor necessary to produce the construction and materials, products, equipment, and systems incorporated or to be incorporated in such construction and including materials, products, equipment, and systems produced both on-and off-site.

1.4 SUBMITTALS

A. Submit the following in accordance with the requirements of this section.

1. Submittal status log: List each submittal. Include for each submittal the specification section number; description of item for which the submittal is required; and the Contractor's scheduled date for the submittal. Submit the log within 15 days after notice to proceed. Indicate required approval date to maintain project schedule.

1.5 PROCEDURES FOR SUBMITTALS

A. Limits and Constraints Regarding Submittals

1. Submittals shall be complete for each portion of the work; components of the work interrelated as a system shall be submitted at the same time.
2. When submittal acceptability is dependent on conditions, items, or materials included in separate subsequent submittals, the submittal will be returned without review.
3. Submittals of information not required as a submittal, or covering work for which the submittals have been returned as “No Exceptions Taken” will be returned without review.
4. Approval of a separate material, product, or component does not imply approval of assembly in which the item functions.
5. The work shall conform to approved submittals, except contractor shall conform to the contract requirements and resubmit the submittal if a previously approved submittal has an error or omission.
6. When submitting for approval material which is other than that cited in the contract, submit the necessary scale drawings, wiring and control diagrams, cuts or entire catalogs, pamphlets, descriptive literature, and performance and test data of both the material specified and the material he wishes to substitute in the number of copies of each as required under the contract.

B. Scheduling of Submittals

1. Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittal processing. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination with another.
2. Except as specified otherwise, allow a review period beginning with receipt by the approval authority that includes at least 20 working days.

C. Substitutions: Substitutions from contract requirements require Government approval and will be considered where advantageous to the Government. Where substitutions are proposed for consideration, submit a written request, with documentation of the nature and features of the substitution and why the substitution is desirable and beneficial to the Government. The proposed substitution shall be identified separately and included along with the required submittal for the item. When a substitution is submitted for approval, the Contractor warrants the following:

1. Substitution Is Compatible: The Contract has been reviewed to establish that the substitution, when incorporated, will be compatible with other elements of the work.
2. Contractor is Responsible: The Contractor shall take action and bear the additional cost, including review costs by the Government, necessary because of the proposed substitution.

D. Resubmittal Costs: Initial submittals requiring Government approval will be reviewed at no cost to the Contractor. The cost of reviewing resubmittals, for reason of failure of the initial submittal to meet contract requirements, shall be the responsibility of the Contractor. The COR will issue a deductive contract modification to reduce the contract price by $500.00 for each resubmittal of items requiring Government review and approval. The contract completion date will not be extended due to non-compliance with submittal requirements.

E. Contractor's Responsibilities:

1. Determine and verify field measurements, materials, field construction criteria; review each submittal; and check and coordinate each submittal with requirements of the work and Contract documents.
2. Ensure that material is clearly legible. Ensure required specialty stamps are affixed and signed.
3. Stamp each sheet of each submittal with the Contractor's certificating stamp, except that data submitted in bound volume or on one sheet printed on two sides may be stamped on the front of the first sheet only. Word the submittal stamp as follows:
   "I hereby certify that the (equipment) (material) (article) shown and marked in this submittal is that proposed to be incorporated into Contract Number ________________, is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is submitted for Government approval.
   Certified by________________________ Date ______________________"
4. Sign the Contractor's certification. The person signing the certification shall be one designated in writing by the Contractor as having that authority. The signature shall be in original ink. Stamped signatures are not acceptable.
5. Transmit submittals to the approving authority in orderly sequence, in accordance with the Submittal Status Log, and to prevent project delays and delays in work by the Government or separate contractors.
6. Advise the approving authority of substitution, as required by the paragraph entitled "Substitutions."
7. Correct and resubmit submittal as directed by the approving authority. Direct specific attention, in writing or on resubmitted submittal, to revisions not requested by the approving authority on previous submissions.
8. Retain a copy of approved submittals at the project site, including the Contractor's copy of approved samples.
9. Furnish additional copies of submittals if requested by the COR.
10. Ensure no work is begun until the submittals for that work have been returned with a review comment other than “Revise and Resubmit” or “Rejected”.

F. Approving Authority's Responsibilities:

1. Submittals will be reviewed for approval with reasonable promptness and only for conformance with project design concepts and compliance with the contract documents. If a substitution is not identified as required by the paragraph entitled "Substitution", then the approval of the submittal SHALL NOT be an approval of the substitution.
2. The checking, marking or approval of the shop drawings and/or product data by the COR shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Approval will not relieve the contractor of the responsibility for any error which may exist. The contractor shall be responsible for the dimensions and design of adequate connections, details, and satisfactory construction of all work.
3. Submittals will be returned with one of the following notations:

   a. Submittals marked “As Submitted” indicate the work may proceed as presented in the submittal.
   b. Submittals marked “Not Approved” indicate the submittal has failed to meet the specification requirements and work may not proceed.
   c. Submittals marked “As Noted” indicate there are markings in the submittal that must be included to result in an acceptable submittal. Contractor may proceed with the work by accepting and incorporating the markings in the finished work unless the “Revise and Resubmit” box is checked.
   d. Submittals marked “Revise and Resubmit” must be modified and resubmitted. The revised submittal number must indicate that it is a resubmittal of a rejected submittal.

G. The transmittal sheet returning the submittal will be initialed.

1.6 FORMAT AND QUANTITY OF SUBMITTALS

A. Transmittal Form: Transmit each submittal, except sample installations and sample panels, to the office of the approving authority. Transmit submittals with a transmittal form approved by the COR and standard for the project. The transmittal form shall identify the Contractor, indicate the date of the submittal, and include information prescribed by the transmitted form and required in the paragraph entitled "Identifying Submittals." Process transmittal forms to record actions regarding sample panels and sample installations.

B. Identifying Submittals: Identify submittals, except sample panel and sample installation, with the following information permanently adhered to or noted on each separate component of each submittal and noted on the transmittal form. Mark each copy of each submittal identically, with the following:

1. Project title and location.
2. Construction contract number.
3. The Section number and paragraph number of the Section by which the submittal is required and the paragraph to which it conforms.
4. The name, address, and telephone number of the subcontractor, supplier, manufacturer and any other second tier contractor associated with the submittal.
5. Product identification and location in project.

C. Format and Quantity for Shop Drawings

1. For shop drawings presented on sheets larger than 11-inches by 17 inches, submit two printed copies and one Portable Document Format (PDF) file transmitted on 700 MB compact disks (CD) or flash drive of each shop drawing prepared for this project.
2. For shop drawings presented on sheets 11-inches by 17 inches or less, submit two printed copies with each bound in a separate volume and a PDF file transmitted on 700 MB compact disks (CD) or flash drive of each shop drawing prepared for this project.
3. Include on each drawing the drawing title, number, date, and revision numbers and dates, in addition to the information required in the paragraph entitled "Identifying Submittals."
4. Dimension drawings, except diagrams and schematic drawings; prepare dimensioned drawings to scale. Identify materials and products for work shown.
5. Shop drawings shall be not less than 8 1/2 by 11 inches or more than 36 by 42 inches.
6. After review, the approving authority will return a PDF file and a marked original.

D. Format and Quantity for Product Data

1. Submit two printed copies with each, bound in a separate volume and a PDF file transmitted on compact disk or flash drive of each Product Data prepared for this project.
2. Present submittals for each Section as a complete, bound volume. Include a table of contents listing page and catalog item numbers for product data.
3. Indicate, by prominent notation, each product that is being submitted; indicate the Section and paragraph numbers to which it pertains.
4. Supplement product data with material prepared for the project to satisfy submittal requirements for which product data does not exist. Note that the material is developed specifically for the project.

E. Format and Quantity of Samples:

1. Furnish samples in the sizes below, unless otherwise specified or unless the manufacturer has prepackaged samples of approximately the same size as specified:

    a. Sample of equipment or device: Full size.
    b. Sample of materials less than 2 by 3 inches: Built up to 8 1/2 by 11 inches.
    c. Sample of materials exceeding 8 1/2 by 11 inches: Cut down to 8 1/2 by 11 inches and adequate to indicate color, texture, and material variations.
    d. Sample of linear devices or materials such as conduit and handrails: 10-inch length or length to be supplied, if less than 10 inches.
    e. Sample of non-solid materials such as sand and paint: Pint.
    f. Color selection samples: 2 inches by 4 inches.
    g. Sample panel: 4 feet by 4 feet.
    h. Sample Installation: 100 square feet.

2. Samples showing range of variation: Where variations are unavoidable due to the nature of the materials, submit sets of samples of not less than three units showing the extremes and middle of the range.

3. Quantity, unless otherwise specified:

    a. Submit two samples, or two sets of samples showing range of variation, of each required item. One approved sample or set of samples will be retained by the approving authority and one will be returned to the Contractor.

b. Submit one sample panel. Include components listed in technical section or as directed.

c. Submit one sample installation, where directed.

4. Reusable samples: Incorporate returned samples into the work only if so specified or indicated. Incorporated samples shall be in undamaged condition at the time of use.

5. Recording of sample installation: Note and preserve the notation of the area constituting the sample installation but remove the notation at the final clean up of the project.

6. When a color, texture or pattern is specified in naming a particular manufacturer and style, include one sample of that manufacturer and style, for comparison.

7. Transmittal Form for samples shall identify manufacturer, model, type, color, etc. sufficient to reorder or replace.

F. Format and Quantity of Administrative and Closeout Submittals

1. Unless otherwise specified, submit administrative and closeout submittals in the format and quantities required for shop drawings.
2. Comply with section entitled “Closeout Procedures”.

G. A Portable Document Format (PDF) file for each shop drawing, product data, and sample transmittals shall be uploaded to FAA’s KSN website.

1.7 PROGRESS PHOTOGRAPHIC SUBMITTALS

A. Still Photographs: Before construction operations have started at the site and at least weekly thereafter, the contractor shall take and provide 25 color photographs showing the existing conditions until completion of the work. An electronic file of each view shall be submitted to the COR promptly after taking the views.

1. Photographs shall be made using a digital camera of at least 4 mega pixel size. All digital images shall be submitted on CD along with the monthly photographs.
2. The contractor shall notify the COR 24 hours in advance of taking any photographs.

B. Ownership of Photographs: Any and all still photographs, digital files, and video tapes taken of the construction area are the property of FAA and shall not be released to any source whatsoever without the prior written permission from the COR. This provision shall prevail for the duration of the contract and indefinitely thereafter.

PART 2 – PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01 33 00

SECTION 01 40 00 - CONTRACTOR QUALITY CONTROL

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1.2 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A. ASTM D 3740 Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

B. ASTM E 329 Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

1.3 SUBMITTALS

A. Contractor Quality Control Plan

B. Contractor Quality Control Personnel

C. Daily Logs

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

3.2 The Contractor is responsible for quality control and must establish and maintain an effective quality control system. The quality control system must consist of plans, procedures, and organization necessary to produce an end product that complies with the contract requirements. The system must cover all construction operations, both onsite and offsite, and must be keyed to the proposed construction sequence. The site project superintendent will be held responsible for the quality of work on the job and is subject to removal by the COR for non-compliance with the quality requirements specified in the contract. The site project superintendent in this context must be the

highest level manager responsible for the overall construction activities at the site, including quality and production. The site project superintendent must maintain a physical presence at the site at all times, except as otherwise acceptable to the COR, and must be responsible for all construction and construction related activities at the site. Similar requirements apply to the quality control manager.
CONTRACTOR QUALITY CONTROL (CQC) PLAN

A. Content of the CQC Plan

1. The CQC Plan must include, as a minimum, the following to cover all construction operations, both onsite and offsite, including work by subcontractors, fabricators, suppliers, and purchasing agents:
2. A description of the quality control organization, including a chart showing lines of authority.
3. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.
4. A copy of the letter to the CQC System Manager signed by an authorized official of the firm which describes the responsibilities and delegates sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop work which is not in compliance with the contract. The CQC System Manager must issue letters of direction to all other various quality control representatives outlining duties, authorities, and responsibilities. Copies of these letters must also be furnished to the Government.
5. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers, and purchasing agents. These procedures must be in accordance with Section 01 33 00, “SUBMITTAL PROCEDURES”.
6. Control, verification, and acceptance testing procedures for each specific test to include the test name, specification paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test. (Laboratory facilities must be approved by the COR.)
7. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests including documentation.
8. Procedures for tracking construction deficiencies from identification through acceptable corrective action. These procedures must establish verification that identified deficiencies have been corrected.
9. Reporting procedures, including proposed reporting formats.
10. A list of the definable features of work. A definable feature of work is a task that is separate and distinct from other tasks, has separate control requirements, and may be identified by different trades or disciplines, or it may be work by the same trade in a different environment. Although each section of the specifications may generally be considered as a definable feature of work, there is frequently more than one definable feature under a particular section. This list will be agreed upon during the coordination meeting.

B. Acceptance of Plan: Acceptance of the Contractor's plan is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. The Government reserves the right to require the Contractor to make changes in his CQC Plan and operations including removal of personnel, as necessary, to obtain the quality specified.

C. Notification of Changes: After acceptance of the CQC Plan, the Contractor must notify the COR in writing of any proposed change. Proposed changes are subject to acceptance by the COR.

3.3 COORDINATION MEETING

A. After the Preconstruction Conference, before start of construction, and prior to acceptance by the Government of the CQC Plan, the Contractor must meet with the COR and discuss the Contractor's quality control system. The CQC Plan must be submitted for review a minimum of 7 calendar days prior to the Coordination Meeting. During the meeting, a mutual understanding of the system details must be developed, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite work, and the interrelationship of Contractor's Management and control with the FAA's Quality Assurance. Minutes of the meeting will be prepared by the Contractor and signed by both the Contractor and the COR. The minutes must become a part of the contract file. There may be occasions when subsequent conferences will be called by either party to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures that may require corrective action by the Contractor.

3.4 INDEPENDENT QUALITY CONTROL ORGANIZATION (CQC)

A. Personnel Requirements: The requirements for the Independent CQC organization are a CQC System Manager and sufficient number of additional qualified personnel to ensure safety and contract compliance. QCQ Manager is required to complete the 16 hour “Construction Quality Management (CQM) for Contractors” course as offered by the Corps of Engineers. Personnel identified in Part D Experience Matrix requiring specialized skills to assure the required work is being performed properly will also be included as part of the CQC organization. The Contractor's CQC staff must maintain a presence at the site at all times during progress of the work and have complete authority and responsibility to take any action necessary to ensure contract compliance. The CQC staff must be subject to acceptance by the COR. The Contractor must provide adequate office space, filing systems and other resources as necessary to maintain an effective and fully functional CQC organization. Complete records of all letters, material submittals, shop drawing submittals, schedules and all other project documentation must be promptly furnished to the CQC organization by the Contractor. The CQC organization must be responsible to maintain these documents and records at the site at all times, except as otherwise acceptable to the COR.

B. CQC System Manager: The Contractor must identify as CQC System Manager an individual within the onsite work organization who must be responsible for overall management of CQC and have the authority to act in all CQC matters for the Contractor. The individual must have a minimum of 8 years experience as a superintendent, inspector, QC Manager, project manager, project engineer or construction manager on similar size and type construction contracts which included the major trades that are part of this Contract. The CQC System Manager must be on the site at all times during construction and must be employed by the prime Contractor. The CQC System Manager must be assigned no other duties. An alternate for the CQC System Manager must be identified in the plan to serve in the event of the System Manager's absence. The requirements for the alternate must be the same as for the designated CQC System Manager.

C. Additional CQC Personnel: In addition to CQC personnel specified elsewhere in this specification, the Contractor must provide as part of the CQC organization specialized personnel to assist the CQC System Manager in the following areas: civil, architectural, structural, mechanical, electrical, and fire protection. These individuals must:

1. Be directly employed by the prime Contractor or a Quality Control sub-contractor but may not be employed by a supplier or other sub-contractor on this project
2. Be responsible to the CQC System Manager

3. Be on site once a week minimum to support construction activities in their areas of responsibility
4. Have the necessary education and/or experience in accordance with the experience matrix listed herein.
5. These individuals must review all submittals in their areas of responsibility prior to submission to the FAA
6. Witness testing of the activities in their areas of responsibility.
7. These individuals may perform other duties but must be allowed sufficient time to perform their assigned quality control duties as described in the Quality Control Plan.
8. All personnel are subject to FAA approval.

D. EXPERIENCE MATRIX

Area	Qualifications
1. Architectural	US Registered Architect with 2 years related experience
2. Mechanical	US Registered Mechanical Engineer with 2 years related experience. Required knowledge of HVAC TAB, HVAC DDC and HVAC commissioning.
3. Electrical	US Registered Electrical Engineer with 2 years related experience
4. Fire Protection	US Registered Fire Protection Engineer (FPE) with 2 years related experience

Personnel indicated above must have no business relationships with any subcontractors involved with this project; or with any equipment device manufacturers, suppliers or installers for any such equipment provided as part of this project.

E. Organizational Changes: When it is necessary to make changes to the CQC staff, the Contractor must revise the CQC Plan to reflect the changes and submit the changes to the COR for acceptance.

3.5 REQUEST FOR INFORMATION (RFI’s) AND SUBMITTALS

A. Submittals must be made as specified in Section 01 33 00 “SUBMITTAL PROCEDURES”. The specialized personnel identified in the Experience Matrix (paragraph 3.4.D) as part of the CQC System must be responsible for reviewing all RFI’s and submittals in their areas of responsibility prior to submission to the FAA.

3.6 CONTROL

A. Contractor Quality Control is the means by which the Contractor ensures that the construction, to include that of subcontractors and suppliers, complies with the requirements of the contract. At least three phases of control must be conducted by the CQC System Manager for each definable feature of work as follows:

B. Preparatory Phase: This phase must be performed prior to beginning work on each definable feature of work; after all required plans/documents/materials are approved/accepted, and after copies are at the work site. This phase must include:

1. A review of each paragraph of applicable specifications, reference codes, and standards. A copy of those sections of referenced codes and standards applicable to that portion of the work to be accomplished in the field must be made available by the Contractor at the preparatory inspection. These copies must be maintained in the field and available for use by Government personnel until final acceptance of the work.
2. A review of the contract drawings.
3. A check to assure that all materials and/or equipment have been tested, submitted, and approved.
4. Review of provisions that have been made to provide required control inspection and testing.
5. Examination of the work area to assure that all required preliminary work has been completed and is in compliance with the contract.
6. A physical examination of required materials, equipment, and sample work to assure that they are on hand, conform to approved shop drawings or submitted data, and are properly stored.
7. A review of the appropriate activity hazard analysis to assure safety requirements are met.
8. Discussion of procedures for controlling quality of the work including repetitive deficiencies. Document construction tolerances and workmanship standards for that feature of work.
9. A check to ensure that the portion of the plan for the work to be performed has been accepted by the COR.
10. Discussion of the initial control phase.
11. The Government must be notified at least 48 hours in advance of beginning the preparatory control phase. This phase must include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. The results of the preparatory phase actions must be documented by separate minutes prepared by the CQC System Manager and attached to the daily CQC report. The Contractor must instruct applicable workers as to the acceptable level of workmanship required in order to meet contract specifications.

C. Initial Phase: This phase must be accomplished at the beginning of a definable feature of work. The following must be accomplished:

1. A check of work to ensure that it is in full compliance with contract requirements. Review minutes of the preparatory meeting.
2. Verify adequacy of controls to ensure full contract compliance. Verify required control inspection and testing.
3. Establish level of workmanship and verify that it meets minimum acceptable workmanship standards. Compare with required sample panels as appropriate.
4. Resolve all differences.
5. Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.
6. The Government must be notified at least 24 hours in advance of beginning the initial phase. Separate minutes of this phase must be prepared by the CQC System Manager and attached to the daily CQC report. Exact location of initial phase must be indicated for future reference and comparison with follow-up phases.
7. The initial phase should be repeated for each new crew to work onsite, or any time acceptable specified quality standards are not being met.

D. Follow-up Phase: Daily checks must be performed to assure control activities, including control testing, are providing continued compliance with contract requirements, until completion of the particular feature of work. The checks must be made a matter of record in the CQC documentation. Final follow-up checks must be conducted and all deficiencies corrected prior to the start of additional features of work that may be affected by the deficient work. The Contractor must not build upon nor conceal non-conforming work.

E. Additional Preparatory and Initial Phases: Additional preparatory and initial phases must be conducted on the same definable features of work if: the quality of on-going work is unacceptable; if there are changes in the applicable CQC staff, onsite production supervision or work crew; if work on a definable feature is resumed after a substantial period of inactivity; or if other problems develop.

3.7 TESTS

A. Testing Procedure: The Contractor must perform specified or required tests to verify that control measures are adequate to provide a product that conforms to contract requirements. Upon request, the Contractor must furnish to the Government duplicate samples of test specimens for possible testing by the Government. Testing includes operation and/or acceptance tests when specified. The Contractor must procure the services of an approved testing laboratory or establish an approved testing laboratory at the project site. The Contractor must perform the following activities and record and provide the following data:

1. Verify that testing procedures comply with contract requirements.
2. Verify that facilities and testing equipment are available and comply with testing standards.
3. Check test instrument calibration data against certified standards.
4. Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.
5. Results of all tests taken, both passing and failing tests, must be recorded on the CQC report for the date taken. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test must be given. If approved by the COR, actual test reports may be submitted later with a reference to the test number and date taken. An information copy of tests performed by an offsite or commercial test facility must be provided directly to the COR. Failure to submit timely test reports as stated may result in nonpayment for related work performed and disapproval of the test facility for this contract.

B. Testing Laboratories

1. Capability Check: The Government reserves the right to check laboratory equipment in the proposed laboratory for compliance with the standards set forth in the contract specifications and to check the laboratory technician's testing procedures and techniques. Laboratories utilized for testing soils, concrete, asphalt, and steel must meet criteria detailed in ASTM D 3740 and ASTM E 329.
2. Capability Recheck: If the selected laboratory fails the capability check, the Contractor will be assessed a charge of $500 to reimburse the Government for each succeeding recheck of the laboratory or the checking of a subsequently selected laboratory. Such costs will be deducted from the contract amount due the Contractor.

C. Onsite Laboratory: The Government reserves the right to utilize the Contractor's control testing laboratory and equipment to make assurance tests, and to check the Contractor's testing procedures, techniques, and test results at no additional cost to the Government.

D. Furnishing or Transportation of Samples for Testing: Costs incidental to the transportation of samples or materials must be borne by the Contractor. Samples of materials for test verification and acceptance testing by the Government must be delivered to the Contracting Officer's Representatives office unless otherwise coordinated.

E. Coordination for each specific test, exact delivery location, and dates will be made through the Contracting Officer's Representative.

3.8 DOCUMENTATION

A. The Contractor must maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records must include the work of subcontractors and suppliers and must be on an acceptable form that includes, as a minimum, the following information:

1. Contractor/subcontractor and their area of responsibility.
2. Operating plant/equipment with hours worked, idle, or down for repair.
3. Work performed each day, giving location, description, and by whom. When Network Analysis (NAS) is used, identify each phase of work performed each day by NAS activity number.
4. Test and/or control activities performed with results and references to specifications/drawings requirements. The control phase must be identified (Preparatory, Initial, and Follow-up). List of deficiencies noted, along with corrective action.
5. Quantity of materials received at the site with statement as to acceptability, storage, and reference to specifications/drawings requirements.
6. Submittals and deliverables reviewed, with contract reference, by whom, and action taken.
7. Offsite surveillance activities, including actions taken.
8. Job safety evaluations stating what was checked, results, and instructions or corrective actions.
9. Instructions given/received and conflicts in plans and/or specifications.
10. Contractor's verification statement.

B. These records must indicate a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. These records must cover both conforming and deficient features and must include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The original and one copy of these records in report form must be furnished to the Government daily within 24 hours after the date covered by the report, except that reports need not be submitted for days on which no work is performed. As a minimum, one report must be prepared and submitted for every 7 days of no work and on the last day of a no work period. All calendar days must be accounted for throughout the life of the contract. The first report following a day of no work must be for that day only. Reports must be signed and dated by the CQC System Manager. The report from the CQC System Manager must include copies of test reports and copies of reports prepared by all subordinate quality control personnel.

3.9 NOTIFICATION OF NONCOMPLIANCE

A. The COR will notify the Contractor of any detected noncompliance with the foregoing requirements. The Contractor must take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the work site, must be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the COR may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders must be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

END OF SECTION 01 40 00

SECTION 01 50 00 - TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for temporary utilities, support facilities, and security and protection facilities.

1.2 DEFINITIONS

A. Permanent Enclosure: As determined by COR, permanent or temporary roofing is complete, insulated, and weathertight; exterior walls are insulated and weathertight; and all openings are closed with permanent construction or substantial temporary closures.

1.3 USE CHARGES

A. General: Cost or use charges for temporary facilities shall be included in the Contract Sum. Allow other entities to use temporary services and facilities without cost, including, but not limited to, testing agencies, and authorities having jurisdiction.
   1. Sewer Service: Pay sewer service use charges for sewer usage by Contractor’s trailers for the duration of construction operations.
   2. Water Service: Pay water service use charges for water used by Contractor’s trailers for the duration of construction operations.
   3. Electric Power Service: Pay electric power service use charges for electricity used by Contractor’s trailers for the duration of construction operations.

1.4 SUBMITTALS

A. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for construction personnel.

1.5 QUALITY ASSURANCE

A. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.

B. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

1.6 PROJECT CONDITIONS

A. Temporary Use of Permanent Facilities: Installer of each permanent service shall assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before FAA's acceptance, regardless of previously assigned responsibilities.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Chain-Link Fencing: Minimum 2-inch, 0.148-inch- thick, galvanized steel, chain-link fabric fencing; minimum eight (8) feet high with galvanized steel pipe posts; minimum 2-3/8-inch- OD line posts and 2-7/8-inch- OD corner and pull posts with galvanized barbed-wire top strand.

B. Portable Chain-Link Fencing: Minimum 2-inch, 9-gage, galvanized steel, chain-link fabric fencing; minimum six (6) feet high with galvanized steel pipe posts; minimum 2-3/8-inch- OD line posts and 2-7/8-inch- OD corner and pull posts, with 1-5/8-inch- OD top and bottom rails. Provide concrete or galvanized steel bases for supporting posts.

C. Wood Enclosure Fence: Plywood, six (6) feet high, framed with four 2-by-4-inch rails, with preservative-treated wood posts spaced not more than eight (8) feet apart.

D. Lumber and Plywood: Comply with requirements in Section 06 10 00 "Rough Carpentry."

E. Gypsum Board: Minimum 1/2 inch thick by 48 inches wide by maximum available lengths; regular-type panels with tapered edges. Comply with ASTM C 36/C 36M.

F. Insulation: Unfaced mineral-fiber blanket, manufactured from glass, slag wool, or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.

G. Paint: Comply with requirements in Division 09 painting Sections.

2.2 TEMPORARY FACILITIES

A. Field Offices, General: Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading.

2.3 TOILET FACILITIES

A. Enclosed portable self-contained units or temporary water closets and urinals, designed either for chemical neutralization or for holding in a temporary tank for pumping by a legally permitted sewage transport company.

B. Provide temporary trailer restrooms for FAA personnel. Women unit to be provided with 2 sinks and 2 stalls, men’s unit to be provided with 2 stalls, 2 sinks, and 2 urinals. Both units to be conditioned and designed either for chemical neutralization or for holding in a temporary tank for pumping by a legally permitted sewage transport company.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.

1. Locate facilities to limit site disturbance.

2. Location of temporary facilities shall be subject to FAA COR review and approval.

B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

3.2 TEMPORARY UTILITY INSTALLATION

A. General: Install temporary service or connect to existing service.

1. Arrange with utility company, FAA, and existing users for time when service can be interrupted, if necessary, to make connections for temporary services.

B. Sewers and Drainage: Provide temporary utilities to remove effluent lawfully.

C. Water Service: Install water service and distribution piping in sizes and pressures adequate for construction.

D. Sanitary Facilities: Provide temporary toilets, wash facilities, and drinking water for use of construction personnel. Comply with authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.

E. Sanitary FAA Personnel Facilities: Provide temporary toilets, wash facilities, and drinking water for use of FAA personnel. Comply with authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.

F. Heating and cooling: Provide temporary heating and cooling required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed.

G. Ventilation and Humidity Control: Provide temporary ventilation required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce ambient condition required and minimize energy consumption.

H. Electric Power Service: Provide electric power service and distribution system of sufficient size, capacity, and power characteristics required for construction operations.

I. Lighting: Provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, inspections, and traffic conditions.

1. Install and operate temporary lighting that fulfills security and protection requirements without operating entire system.
2. Install lighting for Project identification sign.

J. Telephone Service: Provide temporary telephone service in common-use facilities and FAA field representative’s office.

1. At each telephone, post a list of important telephone numbers.

   a. Police and fire departments.
   b. Ambulance service.
   c. Contractor's home office.
   d. COR's office.
   e. Engineers' offices.
   f. Principal subcontractors' field and home offices.

2. Provide superintendent with cellular telephone or portable two-way radio for use when away from field office.

K. Internet Service: Provide internet connection for duration of project in common-use facilities and FAA field representative’s office. Internet service will be of sufficient band width, speed etc. to efficiently view, download edit, etc. all CAD files, schedule files, and all contractor deliverables. The contractor shall supply internet service for all FAA and FAA contractor employees working on site. For planning purposes, the contractor will plan for three (3) connections to the internet all capable of performing required functions under this contract.

3.3 SUPPORT FACILITIES INSTALLATION

A. General: Comply with the following:

1. Provide incombustible construction for offices, shops, and sheds located within construction area or within thirty (30) feet of building lines. Comply with NFPA 241.
2. Maintain support facilities until near Substantial Completion. Remove before Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use permanent facilities, under conditions acceptable to FAA.

B. Traffic Controls: Comply with requirements of authorities having jurisdiction.

1. Protect existing site improvements to remain including curbs, pavement, and utilities.
2. Maintain access for fire-fighting equipment and access to fire hydrants.

C. Parking: Provide temporary parking areas for construction personnel.

D. Waste Disposal Facilities: Provide waste-collection containers in sizes adequate to handle waste from construction operations. Comply with requirements of authorities having jurisdiction.

E. Temporary Elevator Use: Coordinate with FAA COR available times to use ATCT elevators for moving construction materials and personnel.

F. Temporary Use of Permanent Stairs: Cover finished, permanent stairs with protective covering of plywood or similar material so finishes will be undamaged at time of acceptance.

3.4 SECURITY AND PROTECTION FACILITIES INSTALLATION

A. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction in ways and by methods that comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.

1. Comply with work restrictions specified in Section 01 10 00 "Summary of Work."

B. Barricades, Warning Signs, and Lights: Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.

C. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities. Provide temporary weathertight enclosure for building exterior.

1. Where heating or cooling is needed and permanent enclosure is not complete, insulate temporary enclosures.

D. Temporary Fire Protection: Install and maintain temporary fire-protection facilities of types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 241.

1. Prohibit smoking in construction areas.
2. Supervise welding operations, combustion-type temporary heating units, and similar sources of fire ignition according to requirements of authorities having jurisdiction.
3. Develop and supervise an overall fire-prevention and -protection program for personnel at Project site. Review needs with local fire department and establish procedures to be followed. Instruct personnel in methods and procedures. Post warnings and information.
4. Provide temporary standpipes and hoses for fire protection. Hang hoses with a warning sign stating that hoses are for fire-protection purposes only and are not to be removed. Match hose size with outlet size and equip with suitable nozzles.

3.5 OPERATION, TERMINATION, AND REMOVAL

A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.

B. Maintenance: Maintain facilities in good operating condition until removal.

1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a 24-hour basis where required to achieve indicated results and to avoid possibility of damage.

C. Operate Project-identification-sign lighting daily from dusk until 12:00 midnight.

D. Temporary Facility Changeover: Do not change over from using temporary security and protection facilities to permanent facilities until Substantial Completion.

E. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.

1. Materials and facilities that constitute temporary facilities are property of Contractor. FAA reserves right to take possession of Project identification signs.
2. At Substantial Completion, clean and renovate permanent facilities used during construction period. Comply with final cleaning requirements specified in Section 01 77 00 "Closeout Procedures."

END OF SECTION 01 50 00

SECTION 01 52 16 - SAFETY REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

a.	ANSI A10.14	Construction and Demolition Operations – Requirements for Safety Belts, Harnesses, Lanyards and Lifelines for Construction and Demolition Use
b.	ANSI Z359.1	Safety Requirements for Personal Fall Arrest Systems

2. CODE OF FEDERAL REGULATIONS (CFR)

a.	29 CFR 1910	General Industry
b.	29 CFR 1910.94	Ventilation
c.	29 CFR 1910.120	Hazardous Waste Operations and Emergency Response
d.	29 CFR 1926	Construction
e.	29 CFR 1926.65	Hazardous Waste Operations and Emergency Response
f.	29 CFR 1926.502(f)	Warning Line Systems
g.	29 CFR 1926.1200	Hazard Communication Standard (MSDS)

3. CORPS OF ENGINEERS (COE)

a.	COE EM-385-1-1	Safety and Health Requirements Manual

4. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

a.	NFPA 70	National Electrical Code
b.	NFPA 241	Safeguarding Construction, Alteration, and Demolition Operations. Typical items of inclusion include, but are not limited to: Fire Safety Program, Contractor Requirements, Fire Alarm Reporting, Fire Department Access, Hydrants, Standpipes, Fire Extinguishers and Means of Egress.

1.2 DEFINITIONS

A. Certified Safety Professional. A safety manager, safety specialist, or safety engineer that has passed the CSP exam administered by the Board of Certified Safety Professionals.

B. Confined Space. A space which by design has limited openings for entry and exit, unfavorable natural ventilation which could contain or produce dangerous air contaminants, and which is not intended for continuous employee occupancy, engulfment or any other recognized safety or health hazard. Confined spaces include, but are not limited to storage tanks, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines.

C. Multi-employer work site (MEWS). The prime contractor is the "controlling authority" for all work site safety and health of the subcontractors.

D. Recordable Occupational Injuries or Illness. An occupational injury or illnesses which result in serious injuries lost workday cases, non-fatal cases or significant mishaps.

E. Serious Injuries & Fatalities. Regardless of the time between the injury and death or the length of the illness; hospitalization of three or more employees; or property damage in excess of $200,000.

F. Lost Workday Cases. Injuries, other than fatalities, that results in lost workdays.

G. Non-Fatal Cases. Cases without lost workdays which result in transfer to another job or termination of employment, or require medical treatment (other than first aid) or involve property damage in excess of $10,000 but less than $200,000 or involve: loss of consciousness or restriction of work or motion. This category also includes any diagnosed occupational illnesses which are reported to the employer but are not classified as facilities or lost workday cases.

H. Safety Officer. The superintendent or other qualified or competent person who is responsible for the on-site safety required for the project. The contractor quality control person cannot be the safety officer, even though the QC has safety inspection responsibilities as part of the QC duties.

I. Significant Contractor Mishap. A contractor mishap which involves falls of 4 feet or more, electrical mishaps, confined space mishaps, diving mishaps, equipment mishaps, and fire mishaps which result in a lost time injury, or property damage of $10,000 or more, but less than $200,000; or when fire department or emergency medical treatment (EMT) assistance is required.

J. Medical Treatment. Treatment administered by a physician or by registered professional personnel under the standing orders of a physician. Medical treatment does not include first aid treatment provided by a physician or registered personnel.

K. First aid. An on-time treatment, and follow-up visit for the purpose of observation, of minor scratches, cuts, burns, splinters, and so forth, which do not ordinarily require medical care, even though provided by a physician or registered professional personnel.

L. Lost Workdays. The number of days (consecutive or not) after, but not including, the day of injury or illness during which the employee would have worked but could not do so; that is, could not perform all or part of his normal assignment during all or any part of the workday or shift; because of the occupational injury or illness.

M. Environmental Monitoring Services Contractor: Hereafter shall be referred to as the Environmental Contractor, shall be completely independent from the General Contractor and Abatement Contractor and shall not be an employee of the General Contractor or Abatement Contractor or be an employee of principal of a firm recognized by Federal, state, or local regulations that would constitute a business relationship that would be considered independent of the General Contractor or Abatement Contractor Scope of Work.

1.3 SUBMITTALS

A. Statements

1. Accident Prevention Plan (APP): Submit at least 30 calendar days prior to start of work at the job site, follow Appendix A of COE EM-385-1-1, make APP site specific.
2. Activity Hazard Analysis (AHA): Submit the AHA for the preparatory phase as a part of the APP. Submit subsequent AHA for each major phase of work at least 30 calendar days prior to the start of that phase. Format subsequent AHA as amendments to the APP.
3. Health and Safety Plan: The contractor shall develop and implement a comprehensive health and safety plan for his or her employees that cover all aspects of onsite construction operations and activities associated with this contract. This plan must comply with all applicable health and safety regulations and any project-specific requirements that the FAA has specified. The health and safety plan shall include applicable written safety programs in accordance with OSHA regulations.

   This includes but not limited to the following;
   Safety Management, Fall Protection, Personal Protective Equipment Hazard Evaluation, Confined Space, Trenching, Control of Hazardous Energy (Lockout/Tag out), and Hazard Communication.

   Acceptance of the contractor's health and safety plan only signifies that the plan generally conforms to the requirements of the contract. It does not mean that the FAA has verified that the plan meets all applicable OSHA regulations and does not relieve the contractor of the responsibility for providing employees with a safe and healthful work environment. All contract employees must be trained and be familiar with the requirements of the health and safety plan. This concept must be communicated to the contractor by the Contracting Officer and also incorporated into the contract document.

B. Records

1. Daily Confined Space Entry Permit. Submit one copy of each permit attached to each Daily Production Report.
2. Reports. Submit reports as their incidence occurs, in accordance with the requirements of the paragraph entitled, “Reports”.

1.4 QUALITY ASSURANCE

A. Qualifications

1. Qualifications of Safety Officer:

   a. Ability to manage the on-site contractor safety program through appropriate management controls.

b. Ability to identify hazards and have the capability to expend resources necessary to abate the hazards.
c. Must have worked on similar types of projects that are equal to or exceed the scope of the project assigned with the same responsibilities.

2. Qualifications of Qualified Person, Confined Space Entry. The qualified person shall be capable (by education and specialized training) of anticipating, recognizing, and evaluating employee exposure to hazardous substances or other unsafe conditions in a necessary control and protective action to ensure worker safety.

B. Meetings

1. Preconstruction Conference: The safety officer shall attend the preconstruction conference to discuss work procedures and safety.
2. Weekly Safety Meetings: Hold weekly. Provide minutes showing contract title, signatures of attendees and a list of topics discussed.

1.5 ACCIDENT PREVENTION PLAN (APP)

A. Prepare the APP in accordance with the required and advisory provisions of COE EM-385-1-1 including appendix A, “Minimum Basic Outline for Preparation of Accident Prevention Plan,” and as modified herein. Include the associated AHA and other specific plans, programs and procedures listed on Pages A-3 and A-4 of COE EM-385-1-1, some of which are called out below.

B. Contents of the Accident Prevention Plan:

1. Name and safety related qualifications of safety officer (including training and any certifications).
2. Qualifications of competent and of qualified persons.
3. Identify the individual who will complete exposure data (hours worked); accident investigations, reports and logs; and immediate notification of accidents to include subcontractors.
4. Emergency response plan. Conform to COE EM-385-1-1, paragraph 01.E and include a map denoting the route to the nearest emergency care facility with emergency phone numbers. Contractor may be required to demonstrate emergency response.
5. Confined Space Entry Plan. Identify the qualified person’s name and qualifications, training, and experience. Delineate the qualified person’s authority to direct work stoppage in the event of hazardous conditions. Include procedure for rescue by contractor personnel and the coordination with emergency responders. (If there is no confined space work, include a statement that no confined space work exists and none will be created.)
6. Hazardous Material Use. Provisions to deal with hazardous materials, pursuant to the Contract Clause “AMS 52.223-3, Hazardous Material Identification and Material Safety Data.” And the following:

a. Inventory of hazardous materials to be introduced to the site with estimated quantities.
b. Plan for protecting personnel and property during the transport, storage and use of the materials.

c. Emergency procedures for spill response and disposal, including a site map with approximate quantities on site at any given time. The site map will be attached to the inventory, showing where the hazardous substances are stored.
d. Material Safety Data Sheets for inventoried materials not required in other section of this specification.
e. Labeling system to identify contents on all containers on-site.
f. Plan for communicating high health hazards to employees and adjacent occupants.

7. Hazardous Energy Control Plan. For hazardous energy sources, comply with COE EM-385-1-1, paragraph 12.A.07.
8. Critical Lift Procedures. Weight handling critical lift plans will be prepared and signed in accordance with COE EM-385-1-1, paragraph 16.c.18.
9. Alcohol and Drug Abuse Plan

   a. Describe plan for testing with pre-employment screening in accordance with the AMS Clause 3.6.3-16.
   b. Description of the on-site prevention program.

10. Fall Protection Plan. The plan shall be site specific and protect all workers at elevations above 6 feet.
11. Silica Exposure Reduction. The plan shall include specific procedures to prevent employee silica inhalation exposures.
12. Air Quality Monitoring Plan. The Air Quality Monitoring Plan shall be approved by the Environmental Contractor prior to submittal to the FAA. The plan shall include proposed air quality monitoring equipment, contaminants to be measured with maximum concentration limits, and proposed controls and mitigation as appropriate to the Project.

1.6 ACTIVITY HAZARD ANALYSIS (AHA)

A. Prepare for each phase of the work. As a minimum, define activity being performed, sequence of work, specific hazards anticipated, control measures to eliminate or reduce each hazard to acceptable levels, training requirements for all involved, and the competent person in charge of that phase of work. For work with fall hazards, including fall hazards associated with scaffold erection and removal, identify the appropriate fall arrest systems. For work with materials handling equipment, address safeguarding measures related to materials handling equipment. For work requiring excavations, include excavation safeguarding requirements. The appropriate AHA shall be reviewed and attendance documented by Contractor at the preparatory, initial, and follow-up phases of Quality Control inspection.

1.7 DRUG PREVENTION PROGRAM

A. Conduct a proactive drug and alcohol use prevention program for all workers, prime and subcontractor, on the site. Ensure that no employees either use illegal drugs or consume alcohol during work hours. Ensure no employees under the influence of drugs or alcohol during work hours. After accidents, collect blood, urine or saliva specimens and test injured employee influence. A copy of the test shall be made available to the RE upon request.

1.8 FALL HAZARD PREVENTION PROGRAM

A. Scaffolds: A competent person shall delineate the fall protection requirements necessary during the erection and dismantling operation of scaffolds used on the project in the fall protection plan and activity hazard analysis for the phase of work.

B. Training: A competent person shall institute a fall protection program. As part of the Fall Protection Program, contractor shall provide training for each employee who might be exposed to fall hazards.

1.9 DUTIES OF THE SAFETY OFFICER

A. Ensure construction hazards are identified and corrected.

B. Maintain applicable safety reference material on the job site.

C. Maintain a log of safety inspections performed.

D. Attend the pre-construction conference.

E. Generate and approve agenda for safety meetings.

1.10 DISPLAY OF SAFETY INFORMATION

A. Display the following information in clear view of the on-site construction personnel:

1. Map denoting the route to the nearest emergency care facility with emergency phone numbers.
2. AHA
3. Confined space entry permit.

1.11 SITE SAFETY REFERENCE MATERIALS

A. Maintain safety-related references applicable to the project, including those listed in the article "References". Maintain applicable equipment manufacturers' manuals.

1.12 HIGH HAZARD WORK AND LONG DURATION

A. Work under this contract is potentially hazardous. Pursuant to contract clause "AMS 52.236-13, Accident Prevention, Alternate I," submit in writing additional proposals for effecting accident prevention under hazardous conditions. Meet in conference with COR to discuss and develop mutual understanding relative to the administration of the overall safety program.

1.13 EMERGENCY MEDICAL TREATMENT

A. Contractors shall arrange for their own emergency medical treatment. FAA has no responsibility to provide.

1.14 REPORTS

A. Reporting Reports: For OSHA recordable accidents, the prime contractor will conduct a suitable investigation, complete the Contractor Significant Incident Report (CSIR) form and provide to the COR within 5 calendar days of the accident.

B. Notification: Notify COR, within 4 hours, of any accident meeting the definition of OSHA recordable occupational injury or illness. Information shall include Contractor name; contract title; type of contract; name of activity, installation or location where mishap occurred; date and time of mishap; names of personnel injured; extent of property damage, if any; and brief description of mishap (to include type of construction equipment used, participants, etc). In addition to OSHA reporting requirements, initial notification shall be made of any accident involving significant mishaps.

C. Monthly Exposure Report: Monthly exposure reporting, to the COR is required to be attached to the monthly billing request. This report is a compilation of employee-hours worked each month for all site workers, both prime and subcontractor.

D. OSHA Citations and Violations: Provide the COR with a copy of each OSHA citation, OSHA report and Contractor response. Correct violations and citations promptly and provide written corrective actions to the COR.

PART 2 - PRODUCTS

2.1 FALL PROTECTION ANCHORAGE

A. Fall protection anchorages, used by contractors to protect their people, will be left in place and so identified for continued customer use.

2.2 CONFINED SPACE SIGNAGE

A. Provide permanent signs integral to or securely attached to access covers for new confined spaces. Signs wording: "DANGER—PERMIT REQUIRED CONFINED SPACE – DO NOT ENTER –" on bold letters a minimum of one inch in height and constructed to be clearly legible with all paint removed. The signal word "DANGER" and shall be red and readable from 5 feet.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Comply with COE EM-385-1-1, NFPA 241, the accident prevention plan, the activity hazard analysis and other related submittals and activity fire and safety regulations.

B. Hazardous Material Exclusions: Not withstanding any other hazardous material used in this contract, radioactive materials or instruments capable of producing ionizing/non-ionizing radiation as well as materials which contain asbestos, mercury or polychlorinated biphenyls, di-isocynates, lead-based paint are prohibited. Exceptions to the use of any of the above excluded materials may be considered by COR upon written request by Contractor.

C. Unforeseen Hazardous Material: If material that may be hazardous to human health upon disturbance during construction operations is encountered, stop that portion of work and notify the COR immediately. Within 14 calendar days the COR will determine if the material is hazardous. If material is not hazardous or poses no danger, the COR will direct the Contractor to proceed without change. If material is hazardous and handling of the material is necessary to accomplish the work, the COR will issue a modification pursuant to “AMS 52.243-4, Changes” and “AMS 52.236-2, Differing Site Conditions”.

3.2 PRE-OUTAGE COORDINATION MEETING

A. Contractors are required to apply for utility outages a minimum of 15 days in advance. As a minimum, the request should include the location of the outage, utilities being affected, duration of outage and any necessary sketches. Once approved and prior to beginning work on the utility system requiring shut down, the Contractor shall attend a pre-outage coordination meeting with the COR to review the scope of work and the lock out/tag out procedures for work protection.

3.3 PERSONNEL PROTECTION

A. Hazardous Noise: Provide hazardous noise signs, and hearing protection, wherever equipment and work procedures produce sound-pressure levels greater than 85 dBA steady state or 140 dBA impulse, regardless of the duration of the exposure.

B. Fall Protection: Enforce use of the fall protection device named for each activity in the AHA all times when an employee is on a surface 6 feet or more above lower levels. Personal fall arrest systems are required when working from an articulating or extendible boom, scissor lifts, swing stages, or suspended platform. Fall protection must comply with ANSI A10.14.

1. Personal Fall Arrest Device: Equipment, subsystems and components shall meet ANSI Z359.1, Personal Fall Arrest Systems. Only a full-body harness with a shock absorbing lanyard is an acceptable personal fall arrest device. Body belts may only be used as positioning devices only such as for steel reinforcing assembly. Body belts are not authorized as a personal fall arrest device. Harnesses must have upper middle back “D” rings for proper body suspension during a fall. Lanyard must be fitted with a double locking snap hook attachment. Webbing, straps, and ropes must be of synthetic fiber or wire rope.
2. Fall Protection for Roofs:

   a. For work within 6 feet of an edge, on low pitched roofs, personnel shall be protected by use of personal fall arrest systems, guardrails, safety nets. Safety monitoring system is not adequate fall protection and is not authorized.

   b. For work greater than 6 feet from an edge, warning lines shall be erected and installed in accordance with 29 CFR 1926.502(f).

3. Safety Nets: Safety nets shall be provided in unguarded workplaces more than 25 feet above surface.

C. Scaffolding: Employees shall be provided with a safe means of access to the work area on the scaffold. Climbing on any scaffold braces or supports not specifically designed for access is prohibited. Contractor shall ensure that scaffold erection is performed by employees that are qualified. Do not use scaffold without the capability of supporting at least four times the maximum intended load or without appropriate fall protection as delineated in the accepted fall protection plan. Minimum platform size shall be based on the platform not being greater in height than four times the dimension of the smallest width dimension for rolling scaffold. Some Baker type scaffolding has been found not to meet these requirements. Stationary scaffolds must be attached to structural building components to safeguard against tipping forward or backward. The first tie-in shall be at the height equal to 4 times the width of the scaffold base.

D. Use of Material Handling Equipment

1. Material handling equipment such as forklifts shall not be modified with work platform attachments for supporting employees unless specifically delineated in the manufacturers printed operating instructions. Crane supported work platforms shall only be used in extreme conditions if the Contractor proves that using any other access to the work location would provide a greater hazard to the workers.
2. Cranes must be equipped with Load Indicating Devices, anti-two blocks devices, load and boom angle moment indicating indicators.

E. Excavations: The competent person for excavation shall be on site when work is being performed in excavation, and shall inspect excavations prior to entry by workers. Individual must evaluate for all hazards, including atmospheric, necessary to correct hazards promptly.

F. Conduct of Electrical Work: Underground electrical spaces must be certified safe for entry before entering to conduct work. Cable intended to be cut must be positively identified and de-energized prior to performing each cut. Perform all high voltage cutting remotely. When racking in or live switching of circuit breakers, no additional person other than the switch operator will be allowed in the space during the actual operation. Plan so that work near energized parts is minimized to the fullest extent possible. Use of electrical outages clear of any energized electrical sources is the preferred method. When working in energized substations, only qualified electrical workers shall be permitted to enter. When work requires Contractor to work near energized circuits as defined by the NFPA 70, high voltage personnel must use personnel protective equipment that includes, as a minimum, electrical hard hat, safety shoes, insulating gloves with leather protective sleeves, fire retarding shirts, coveralls, face shields, and safety glasses. Insulating blankets, hearing protection, and switching suits may be required, depending on the specific job and as delineated in the Contractor AHA.

G. Work in Manholes: Contractor shall provide mechanical ventilation for all work accomplished in manholes, unless other hazards are present like friable asbestos.

H. Work in Confined Spaces: Comply with the requirements in Section 06.I of COE EM-385-1-1. Any potential for a hazard in the confined space requires a permit system to be used.

1. Entry Procedures. Prohibit entry into a confined space by personnel for any purpose, including hot work, until the qualified person has conducted appropriate tests to ensure the confined or enclosed space is safe for the work intended and that all potential hazards are controlled or eliminated and documented. (See Section 06.I.05 of COE EM-385-1-1 for entry procedures.) All hazards pertaining to the space shall be reviewed with each employee during review of the AHA.
2. Forced air ventilation is required for all confined space entry operations and the minimum air exchange requirements must be maintained.

3. Ensure the use of rescue and retrieval devices in confined spaces greater than 5 feet in depth. Conform to Sections 06.I.09, 06.I.10 and 06.I.11 of COE EM-385-11.
4. Include training information for employees who will be involved as entrant attendants for the work. Conform to Section 06.I.06 of COE EM-385-1-1.
5. Entry Permit. Use ENGFORM 5044-R or other form with the same minimum information for the Daily Confined Space Entry Permit, completed by the qualified person. Post the permit in a conspicuous place close to the confined space entrance.

I. Crystalline Silica: Grinding, abrasive blasting, and foundry operations of construction materials containing crystalline silica, shall comply with OSHA regulations, such as 29 CFR 1910.94, and COE EM-385-1-1, (Appendix C). The Contractor shall develop and implement effective exposure control and elimination procedures to include dust control systems, engineering controls, and establishment of work area boundaries, as well as medical surveillance, training, air monitoring, and personal protective equipment.

3.4 ACCIDENT SCENE PRESERVATION

A. For serious accidents, ensure the accident site is secured and evidence is protected remaining undisturbed until released by the COR. After release is issued, promptly replace used, damaged, or worn equipment.

END OF SECTION 01 52 16

SECTION 01 56 23 - BARRIERS AND ENCLOSURES

PART 1 - GENERAL

1.1 REQUIREMENTS INCLUDED

A. Barriers

B. Protected Walkways

C. Security Fencing

D. Weather Closures

E. Maintenance

F. Removal

G. Site Restoration

PART 2 - PRODUCTS

2.1 MATERIALS

A. May be new or used as may be dictated by all governing codes, adequate to the purpose, which will not create hazardous conditions.

PART 3 - EXECUTION

3.1 MARKING FOR HAZARDS

A. Furnish, erect, and maintain all barricades, warning signs and markings for hazards necessary to protect the public and the work. When used during periods of darkness, such barricades, warning signs and hazard markings shall be suitably illuminated.

B. Furnish, erect, and maintain markings and associated lighting of open trenches, excavations, temporary stock piles, and parked construction equipment that may be hazardous to the operation of emergency fire-rescue or maintenance vehicles on the airport in reasonable conformance to FAA Advisory Circular 150/5370-2C, Operational Safety on Airports during Construction. Identify each motorized vehicle or piece of construction equipment in reasonable conformance to FAA Advisory Circular 150-5370-2C.

3.2 BARRIERS AND PROTECTED WALKWAYS

A. Provide to prevent public entry, to protect existing trees and plants, and to protect existing facilities and adjacent properties from damage.

B. Provide fence enclosing construction area of height and type required to maintain site security.

3.3 WEATHER CLOSURES - AS NEEDED

A. Provide temporary roofing and weathertight insulated closures of openings in exterior surfaces to maintain specified working conditions to protect products and finished work from inclement weather.

3.4 MAINTENANCE

A. Maintain during progress of work. Repaint painted surfaces as directed by the COR.

B. Relocate and extend during successive stages of construction.

3.5 REMOVAL

A. Remove temporary materials, equipment and construction at Final Acceptance. Repair or replace damage caused by installation or use of barricades and enclosures. Remove fence post setting.

3.6 SITE RESTORATION

A. Restore site and existing facilities to remain but damaged during construction to specified condition.

END OF SECTION 01 56 23

SECTION 01 57 19 - TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. CODE OF FEDERAL REGULATIONS (CFR)

a.	29 CFR 1910	Occupational Safety and Health Standards
b.	40 CFR 122.26	EPA National Pollutant Discharge Elimination System Permit Regulations
c.	40 CFR 241	Guidelines for Disposal of Solid Waste
d.	40 CFR 243	Guidelines for the Storage and Collection of Residential, Commercial, and Institutional Solid Waste
e.	40 CFR 258	Subtitle D Landfill Requirements
f.	40 CFR 261	Identification and Listing of Hazardous Waste
g.	40 CFR 262	Generators of Hazardous Waste
h.	40 CFR 263	Transporters of Hazardous Waste
i.	40 CFR 264	Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
j.	40 CFR 265	Interim Status Standard for Owners and Operators of Hazardous Waste Management Facilities
k.	40 CFR 266	Management of Specific Hazardous Waste and Specific Types of Hazardous Waste Management Facilities
l.	40 CFR 268	Land Disposal Restrictions
m.	40 CFR 279	Used Oil Regulations
n.	40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
o.	40 CFR 372 SUBPART D	EPA Toxic Chemical Release Reporting Regulations
p.	49 CFR 173	Shipments and Packaging’s

1.2 DEFINITIONS

A. Solid Waste: Garbage, refuse, debris, sludge or other discharged material (except hazardous waste as defined in paragraph entitled “Hazardous Waste” or hazardous debris as defined in paragraph entitled “Hazardous Debris”), including solid, liquid, semisolid, or contained gaseous materials resulting from domestic, industrial, commercial, mining, or agricultural operations. Material not regulated as solid waste are: nuclear source or byproduct materials regulated under the Federal Atomic Energy Act of 1954 as amended; suspended or dissolved materials in domestic sewage effluent or irrigation return flows, or other regulated point source discharges; regulated air emissions; and fluids or wastes associated with natural gas or crude oil exploration or production.

B. Inert construction and demolition debris: Broken or removed concrete, masonry, and rock asphalt paving; ceramics; roofing paper and shingles. All in accordance with state requirements.

C. Wood: Dimension and non-dimension lumber, plywood, chipboard, hardboard. Treated and/or painted wood that meets the definition of lead contaminated or lead based contaminated paint is not included.

D. Scrap metal: Scrap and excess ferrous and non-ferrous metals such as reinforcing steel, structural shapes, pipe and wire that are recovered or collected and disposed of as scrap. Scrap metal meeting the definition of hazardous material or hazardous waste is not included.

E. Paint cans: Metal cans that are empty of paints, solvents, thinners and adhesives. If permitted by the paint can label, a thin dry film may remain in the can.

F. Recyclables: Materials, equipment and assemblies such as doors, windows, door and window frames, plumbing fixtures, glazing and mirrors that are recovered and sold as recyclable. Metal meeting the definition of lead contaminated or lead based paint contaminated must be disposed in accordance with state requirements.

G. Debris: Non-hazardous solid material generated during the construction, demolition, or renovation of a structure which exceeds 2.5 inch particle size that is: a manufactured object; plant or animal matter; or natural geologic material (e.g., cobbles and boulders). A mixture of debris and other material such as soil or sludge is also subject to regulation as debris if the mixture is comprised primarily of debris by volume, based on visual inspection.

K. Hazardous Debris: As defined in paragraph entitled “Debris” of this section, debris that contains listed hazardous waste (either on the debris surface, or in its interstices, such as pore structure) per 40 CFR 261; or debris that exhibits a characteristic of hazardous waste per 40 CFR 261.

L. Chemical Wastes: This includes salts, acids, alkalies, herbicides, pesticides, and organic chemicals.

M. Garbage: Refuse and scraps resulting from preparation, cooking, dispensing, and consumption of food.

N. Hazardous Waste: Hazardous waste as defined in 40 CFR 261 or as defined by applicable state and local regulations.

O. Oily Waste: Petroleum products and bituminous materials.

P. Class I Ozone Depleting Substance (ODS)

1. Class I ODS is defined in Section 602(a) of The Clean Air Act and includes the following chemicals:

Chlorofluorocarbon-11 (CFC-11)	Chlorofluorocarbon-213 (CFC-213)
Chlorofluorocarbon-12 (CFC-12)	Chlorofluorocarbon-214 (CFC-214)
Chlorofluorocarbon-13 (CFC-13)	Chlorofluorocarbon-215 (CFC-215)

Chlorofluorocarbon-111 (CFC-111)	Chlorofluorocarbon-216 (CFC-216)
Chlorofluorocarbon-112 (CFC-112)	Chlorofluorocarbon-217 (CFC-217)
Chlorofluorocarbon-113 (CFC-113)	Halon-1211
Chlorofluorocarbon-114 (CFC-114)	Halon-1301
Chlorofluorocarbon-115 (CFC-115)	Halon=2402
Chlorofluorocarbon-211 (CFC-211)	Carbon tetrachloride
Chlorofluorocarbon-212 (CFC-212)	Methyl chloroform

1.3 SUBMITTALS

A. Statements

1. Dirt and Dust Control Plan
   a. Dirt and Dust Control Plan: Submit a plan for controlling dirt, debris, and dust within the ATCT, Base Building, and ESU building. As a minimum, identify in the plan the subcontractor and equipment for cleaning and measures to reduce dirt, dust, and debris from ATCT, Base Building, and ESU building.

B. Field Test Reports

1. Laboratory Analysis

   a. Submit a copy of a laboratory analysis of solid waste and debris with the potential of becoming classified as a hazardous waste (i.e., abrasive/sand blasting debris, etc.). Waste stream determinations are required at the point of generation and must sufficiently document whether the waste will be a solid waste, hazardous waste, or Resource Conservation and Recovery Act (RCRA) exempt waste. Determinations must use EPA approved methods and provide written rational for whether the waste is classified as hazardous or non-hazardous. The Contractor shall bear the cost of the waste stream determinations, and the COR reserves the right to request waste stream determinations on questionable waste streams.

C. Records

1. Some of the records listed below are also required as part of other submittals. For the "Records" submittal, maintain on-site a separate three-ring Environmental Records binder and submit at the completion of the project. Make separate parts to the binder corresponding to each of the applicable sub items listed below:

   a. Preconstruction survey
   b. Solid waste disposal permit
   c. Waste determination documentation
   d. Disposal documentation for hazardous and regulated waste
   e. Regulatory notification
   f. Solid waste disposal report

2. Preconstruction Survey: Perform a preconstruction survey of the project site with the COR

and take photographs showing existing environmental conditions within the work area. Submit a report for the record.

3. Solid Waste Disposal Permit: Submit one copy of a permit or license showing such agency's approval of the disposal plan before transporting wastes off Government property.
4. Waste Determination Documentation: The Contractor shall complete a Waste Determination form (provided at the pre-construction conference) for all contractor derived wastes to be generated. The waste determination must be based upon either a constituent listing from the manufacturer used in conjunction with consideration of the process by which the waste was generated, EPA approved analytical data, or laboratory analysis (Material Safety Data Sheets (MSDS) by themselves are not adequate). All support documentation must be attached to the Waste Determination form. As a minimum, a Waste Determination form must be provided for the following wastes (this listing is not all inclusive): oil and latex based painting and caulking products, solvents, adhesives, aerosols, petroleum products, and all containers of the original materials.
5. Disposal Documentation for Hazardous and Regulated Waste: Submit a copy of the applicable EPA and state permit(s), manifest(s), or license(s) for transportation, treatment, storage, and disposal of hazardous and regulated waste by permitted facilities.
6. Regulatory Notification: The Contractor is responsible for all regulatory notification requirements in accordance with Federal, state and local regulations. The Contractor shall forward copies to the COR prior to commencement of work activities. Typically, regulatory notifications must be provided for the following (this listing is not all inclusive): demolition, renovation, NPDES defined site work, remediation of controlled substances (asbestos, hazardous waste, lead paint).
7. Solid Waste Disposal Report: Monthly the Contractor shall submit a solid waste disposal report to the COR. For each waste, the report shall state the classification (using the definitions provided in this section), amount, location, and name of the business receiving the solid waste. The Contractor shall include copies of the waste handling facilities' weight tickets, receipts, bills of sale, and other sales documentation. In lieu of sales documentation, the Contractor may submit a statement indicating the disposal location for the solid waste which is signed by an officer of the Contractor firm authorized to legally obligate or bind the firm. The sales documentation or Contractor certification shall include the receiver's tax identification number and business, EPA or state registration number, along with the receiver's delivery and business address and telephone numbers. For each solid waste retained by the Contractor for his own use, the Contractor shall submit on the solid waste disposal report the information previously described. Prices paid or received shall not be reported to the COR unless required by other provisions or specifications of this Contract or public law.

1.4 CLASS I ODS PROHIBITION

A. Class I ODS as defined and identified herein shall not be used in the performance of this contract, nor be provided as part of the equipment. This prohibition shall be considered to prevail over any other provision, specification, drawing, or referenced documents.

1.5 ENVIRONMENTAL PROTECTION REQUIREMENTS

A. Provide and maintain, during the life of the contract, environmental protection as defined. Plan for and provide environmental protective measures to control pollution that develops during normal construction practice. Plan for and provide environmental protective measures required to correct conditions that develop during the construction of permanent or temporary environmental features associated with the project. Comply with Federal, state, and local regulations pertaining to the environment, including water, air, solid waste, hazardous waste and substances, oily substances, and noise pollution.

B. Licenses and Permits: Obtain licenses and permits pursuant to the “Permits and Responsibilities” AMS Clause.

C. Contractor Liabilities for Environmental Protection: The Contractor is advised that this project and the facility are subject to federal, state, and local regulatory agency inspections to review compliance with environmental laws and regulations. The Contractor shall fully cooperate with any representative from and federal, state and local regulatory agency who may visit the job site and shall provide immediate notification to the COR, who shall accompany them on any subsequent site inspections. The Contractor shall complete, maintain and make available to the COR, station, or regulatory agency personnel all documentation relating to environmental compliance under applicable federal, state and local laws and regulations. The Contractor shall immediately notify the COR if a Notice of Violation (NOV) is issued to the Contractor.

D. The Contractor shall be responsible for all damages to persons or property resulting form Contractor fault or negligence as well as for the payment of any civil fines or penalties which may be assessed by any federal, state or local regulatory agency as a result of the Contractor’s or any subcontractor’s violation of any applicable federal, state, or local environmental law or regulation. Should a Notice of Violation (NOV), Notice of Noncompliance (NON), Notice of Deficiency (NOD), or similar regulatory agency notice be issued to the FAA or FAA as facility owner/operator on account of the actions or inactions of the Contractor or one of its subcontractors in the performance of work under this contract, the Contractor shall fully cooperate with the FAA and/or FAA in defending against regulatory assessment of any civil fines or penalties arising out of such actions or inactions.

1.6 ENVIRONMENTAL PROTECTION PLAN

A. The Environmental Protection Plan shall be submitted in the following format and shall, at a minimum, address the following elements:

1. Description of the Environmental Protection Plan
    a. General overview and purpose
    b. General site information

B. Prevention of Releases to the Environment

1. Procedures to prevent releases to the environment
2. Notifications in the event of a release to the environment

C. Protection of the Environment from Waste (Hazardous Waste Management Section)

1. Control and disposal of solid and sanitary waste
2. Control and disposal of hazardous waste (Hazardous Waste Management Section)

This item shall consist of the management procedures for all hazardous waste to be generated. As a minimum, include the following:

a. Procedures to be employed to ensure a written waste determination is made for appropriate wastes which are to be generated;
b. Sampling/analysis plan;
c. Methods of hazardous waste accumulation/storage (i.e., in tanks and/or containers);
d. Management procedures for storage, labeling, transportation, and disposal of waste (treatment of waste is not allowed unless specifically noted);
e. Management procedures and regulatory documentation ensuring disposal of hazardous waste complies with Land Disposal Restrictions (40 CFR 268);
f. Management procedures for recyclable hazardous materials such as lead-acid batteries, used oil, and the like;
g. Used oil management procedures in accordance with 40 CFR 279;
h. Pollution prevention/hazardous waste minimization procedures;
i. Plans for the disposal of hazardous waste by permitted facilities;
j. Procedures to be employed to ensure all required employee training records are maintained.

D. Environmental Protection Plan Review: Fourteen days after the environmental protection meeting, submit the proposed Environmental Protection Plan for further discussion, review, and approval. Commencement of work shall not begin until the environmental protection plan has been approved.

1.7 UNFORESEEN HAZARDOUS OR REGULATED MATERIAL

A. If material that is not indicated in the contract documents is encountered that may be dangerous to human health upon disturbance during construction operations, stop that portion of work and notify the COR immediately. Intent is to identify materials such as PCB, lead paint, mercury, petroleum products, and friable and nonfriable asbestos. Within fourteen (14) calendar days the FAA will determine if the material is hazardous. If the material is not hazardous or poses no danger, the FAA will direct the Contractor to proceed without change. If the material is hazardous and handling of the material is necessary to accomplish the work, the FAA will issue a modification pursuant of “AMS 52.243-4, Changes” and “AMS 52.236-2, Differing Site Conditions”.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 CONTROL AND DISPOSAL OF SOLID WASTES

A. Pick up solid wastes, and place in covered containers which are regularly emptied. Do not prepare or cook food on the project site. Prevent contamination of the site or other areas when handling and disposing of wastes. At project completion, leave the areas clean. Recycling is encouraged and can be coordinated with the COR and the activity recycling coordinator. Remove all solid waste (including non-hazardous debris) from FAA property and dispose off-site at an approved landfill. Solid waste disposal off-site must comply with most stringent local state, and federal requirements including 40 CFR 241, 40 CFR 243, and 40 CFR 258.

B. Dumpsters: Equip dumpsters with a secure cover. Keep cover closed at all times, except when being loaded with trash and debris. Locate dumpsters behind the construction fence or out of the public view. Empty site dumpsters at least once a week or as needed to keep the site free of debris and trash. If necessary, provide 55 gallon trash containers to collect debris in the construction site area. Locate the trash containers behind the construction fence or out of the public view. Empty trash containers at least once a day. For large demolitions, large dumpsters without lids are acceptable but should not have debris higher than the sides before emptying.

3.2 CONTROL AND DISPOSAL OF HAZARDOUS WASTES

A. Hazardous Waste/Debris Management: The Contractor shall identify all construction activities that will generate hazardous waste/debris. The Contractor must provide a documented waste determination for all resultant waste streams. Hazardous waste/debris shall be identified, labeled, handled, stored, and disposed of in accordance with all Federal, State and local regulations including 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, 40 CFR 266, and 40 CFR 268. Hazardous waste shall also be managed in accordance with the approved Hazardous Waste Management Section of the Environmental Protection Plan. Store hazardous wastes in approved containers in accordance with 49 CFR 173. Hazardous waste generated within the confines of the facilities shall be identified as being generated by the Contractor. Prior to removal of any hazardous waste from FAA property, all hazardous waste manifests must be signed by the Contractor and a copy given to the COR. No hazardous waste shall be brought onto FAA's property. Provide to the COR a copy of waste determination documentation for any solid waste streams that have any potential to be hazardous waste or contain any chemical constituents listed in 40 CFR 372-SUBPART D. For hazardous wastes spills, verbally notify the COR immediately.

1. Regulated Waste Storage/Satellite Accumulation/90 Day Storage Areas: If the work requires the temporary storage/collection of regulated or hazardous wastes, the Contractor may request the establishment of a Regulated Waste Storage Area, a Satellite Accumulation Area, or a 90 Day Storage Area at the point of generation. The Contractor must submit a request in writing to the COR providing the following information:

Contract Number	____________	Contractor	____________
Haz/Waste or Regulated Waste POC	____________	Phone Number	____________
Type of Waste	____________	Source of Waste	____________
Emergency POC	____________	Phone Number	
Location of the Site	____________		

(Attach Site Plan to the Request)

2. Attach a waste determination form. Allow ten working days for processing this request.

B. Pollution Prevention/Hazardous Waste Minimization: The Contractor shall actively pursue minimizing the use of hazardous materials and the generation of hazardous waste while on-base. The Hazardous Waste Management Section of the Environmental Protection Plan shall include the Contractor's procedures for pollution prevention/hazardous waste minimization. The Contractor shall describe the types of the hazardous materials expected to be used in the construction when requesting information.

C. Hazardous Material Control: The Contractor shall include hazardous material control procedures in the Safety Plan. The procedures shall address and ensure the proper handling of hazardous materials, including the appropriate transportation requirements. The Contractor shall submit a MSDS and estimated quantities to be used for each hazardous material to the COR prior to bringing the material on base. Typical materials requiring MSDS and quantity reporting include, but are not limited to, oil and latex based painting and caulking products, solvents, adhesives, aerosol, and petroleum products. At the end of the project, the Contractor shall provide the COR with the maximum quantity of each material that was present at the site at any one time, the dates the material was present, the amount of each material that was used during the project, and how the material was used. The Contractor shall also ensure that hazardous materials are utilized in a manner that will minimize the amount of hazardous waste that is generated. The Contractor shall ensure that all containers of hazardous materials have NFPA labels or their equivalent. Copies of the MSDS for hazardous materials shall be kept on site at all times and provided to the COR at the end of the project. The Contractor shall certify that all hazardous materials removed from the site are hazardous materials and do not meet the definition of hazardous waste per 40 CFR 261.

D. Petroleum Products: Conduct the fueling and lubricating of equipment and motor vehicles in a manner that protects against spills and evaporation. All used oil generated on the site shall be managed in accordance with 40 CFR 279. The Contractor shall determine if any used oil generated while on-site exhibits a characteristic of hazardous waste. In addition, used oil containing 1000 parts per million of solvents will be considered a hazardous waste and disposed of at Contractor's expense. Used oil mixed with a hazardous waste will also be considered a hazardous waste. All hazardous waste will be managed in accordance with the paragraph entitled Hazardous Waste/Debris Management of this section and shall be managed in accordance with the approved Environmental Protection Plan.

E. Spills of Oil and Hazardous Materials: Take precautions to prevent spills of oil and hazardous material. In the event of a spill, immediately notify the COR. Spill response shall be in accordance with 40 CFR 300 and applicable State Regulations.

3.3 DUST CONTROL

A. Keep dust down at all times, including during nonworking periods. Dry power brooming will not be permitted. Instead, use vacuuming, wet mopping, wet sweeping, or wet power brooming.

3.4 ABRASIVE BLASTING

A. Blasting Operations

1. The use of silica sand is prohibited in sandblasting.
2. Provide tarpaulin drop cloths and windscreens to enclose abrasive blasting operations to confine and collect dust, abrasive, agent, paint chips, and other debris.

B. Disposal Requirements: Submit analytical results of the debris generated from abrasive blasting operations per paragraph entitled Laboratory Analysis of this section. Hazardous waste generated from blasting operations shall be managed in accordance with paragraph entitled “Hazardous Waste\Debris Management” of this section and with the approved HWMP. Disposal of non-hazardous abrasive blasting debris shall be in accordance with paragraph entitled, “Control and Disposal of Solid Wastes”.

END OF SECTION 07 57 19

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SECTION 01 58 13 - POSTING OF NOTICES

PART 1 - GENERAL

1.1 SCHEDULE OF WAGE RATES AND BENEFITS

A. The Contractor and each subcontractor under him shall post in a conspicuous place on the site (1) the schedule of the specified overall hourly rate for each applicable classification; (2) the amount of liquidated damages for any failure to pay such rates; and (3) the name and address of the responsible official in the County or the U.S. Department of Labor (whichever is applicable) to whom complaints should be given.

B. Copy of this Notice will be provided to the Contractor by the FAA.

1.2 NON-DISCRIMINATION CLAUSE

A. In accordance with AMS Clause No. 3.6.2-9 Equal Opportunity, the Contractor shall post the non-discrimination clause as required by Executive Order 11246.

B. The following is a statement of the required clause: Equal Employment Opportunity is the Law -- Discrimination is prohibited by the Civil Rights Act of 1964 and by Executive Order No. 11246. Title VII of the Civil Rights Act of 1964 -- Administered by: The Equal Employment Opportunity Commission. Prohibits discrimination because of Race, Color, Religion, Sex, or National Origin by Employers with 25 or more employees, by Labor Organizations with a hiring hall of 25 or more members, by Employment Agencies, and by Joint Labor-Management Committees for Apprenticeship or Training. Any person who believes he or she has been discriminated against should contact: The Equal Employment Opportunity Commission. 2401 E Street, NW, Washington, DC 20506.

C. EXECUTIVE ORDER NO. 11246--Administered by: The Office of Federal Contract Compliance Programs prohibits discrimination because of Race, Color, Religion, Sex, or National Origin, and requires affirmative action to ensure equality of opportunity in all aspects of employment by all Federal Government Contractors and Subcontractors, and by Contractors Performing Work Under a Federal Assisted Construction Contract, regardless of the number of employees in either case. Any person who believes he or she has been discriminated against should contact: The Office of Federal Contract Compliance Programs, U.S. Department of Labor, Washington, DC 20210.

PART 2 – PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 01 58 13

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SECTION 01 71 33 - PROTECTION OF WORK AND PROPERTY

PART 1 - GENERAL

1.1 REQUIREMENT INCLUDED

A. Protection of products after installation.

B. Protection of existing property and landscape.

C. Storm Protection Plan.

1.2 SUBMITTALS

A. Contractor shall submit a Storm Protection Plan to the COR for approval within fifteen (15) calendar days after notice to proceed.

B. Storm Protection Plan shall include, as a minimum, the following:

1. Storm Plan objectives.
2. Methods to attain protection objectives.
3. Responsibility of key personnel for the Contractor.
4. Time frame required to secure the site.
5. Time frame required to lower and/or secure crane(s).
6. Disaster and emergency programs.
7. Lists of key personnel to be contacted in time of emergency.

PART 2 - PRODUCT

NOT USED

PART 3 - EXECUTION

3.1 PROTECTION AFTER INSTALLATION

A. Protect installed products and control traffic in immediate area to prevent damage from subsequent operations.

B. Provide protective coverings at walls, projections, corners and jambs, sills and soffits of openings in and adjacent to traffic areas.

C. Cover walls and floors of elevator cabs and jambs of cab doors with 3/4 inch plywood, when elevators are used by construction personnel.

D. Protect finished floors and stairs from dirt, wear and damage:

1. Secure heavy sheet goods or similar protective materials in areas subject to foot traffic.

2. Lay planking or similar rigid materials in areas subject to movement of heavy objects.
3. Lay planking or similar rigid materials in place, in areas where storage of products will occur.

E. Protect waterproofed and roofed surfaces:

1. Restrict use of surfaces from traffic of any kind and from storage of products.
2. When an activity is mandatory, obtain recommendations for protection of surfaces from manufacturer. Install protection and remove on completion of activity. Restrict use of adjacent unprotected areas.

F. Restrict traffic of any kind across planted lawn and landscape areas.

3.2 PROTECTION AND RESTORATION OF PROPERTY

A. The Contractor shall be responsible for the preservation of all public and private property, and shall protect carefully from disturbance or damage all land monuments and property markers until the COR has witnessed or otherwise referenced their location and shall not move them until directed.

B. The Contractor shall be responsible for all damage or injury to property of any character, during the prosecution of the work, resulting from any act, omission, neglect, or misconduct in its manner or method of executing the work, or at any time due to defective work or materials, and said responsibility will not be released until the work is completed and accepted.

C. When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work, or in consequence of the nonexecution thereof by the Contractor, the Contractor shall restore, at its own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, or otherwise restoring as may be directed, or it shall make good such damage or injury in an acceptable manner, at no additional cost to the government.

3.3 STORM PROTECTION PLAN

A. The Contractor shall take all precautions as necessary to prevent damage to the facility and shall be responsible for damage to the facility resulting from any act, omission, neglect, or misconduct in the execution of the approved Storm Protection Plan.

B. In the event of a severe storm warning or as directed by the COR, the Contractor shall:

1. Secure outside equipment and materials and place materials subject to possible damage in protected locations.
2. Check surrounding area, including roof, for loose material, equipment, debris, and other objects that could be blown away or against existing facilities.
3. Secure crane(s).
4. Ensure that temporary erosion controls are adequate.
5. After the storm, the Contractor may be directed by the COR to assist in the restoration of the existing facility. Any restoration shall take precedence over the construction contract. Any additional costs will be claimed under the “changes” clause of the contract.

END OF SECTION 01 71 33

SECTION 01 74 13 - CONSTRUCTION CLEANING

PART 1 - GENERAL

1.1 REQUIREMENT INCLUDED

A. Cleaning and disposal of waste materials, debris and rubbish during construction.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Provide covered containers for deposit of waste materials, debris and rubbish.

PART 3 - EXECUTION

3.1 CLEANING

A. Maintain areas under Contractor's control free of waste materials, scraps, surplus material, debris and rubbish. Maintain site in a clean and orderly condition.

B. Remove debris and rubbish from pipe chases, plenums attics, crawl spaces and other closed or remote spaces, prior to closing the space.

C. Clean interior areas daily to provide suitable conditions for work and to prevent fire or accidents.

D. Use power brooms to clean paved areas as needed and immediately prior to opening any paved area to aircraft or vehicular traffic.

E. All combustible waste materials shall be removed from buildings at the end of each working day.

F. Broom clean interior areas prior to start of surface finishing and continue cleaning on a daily basis.

G. Control cleaning operations so that dust and other particulates will not adhere to wet or newly-coated surfaces.

H. Responsibility for construction cleaning shall not be delegated to subcontractors performing construction work under this Contract.

3.2 DISPOSAL

A. Remove waste materials, debris and rubbish from site bi-weekly and legally dispose of off-site in an authorized disposal area.

3.3 CONTRACTOR'S FAILURE TO CLEAN

A. If the Contractor fails to maintain levels of cleanliness in work areas, satisfactory to the COR, then the FAA shall have the right to cause such areas to be cleaned by others. The costs to the FAA for such cleaning, plus 25% for administration, shall be the obligation of the Contractor and shall be deducted from any money due the Contractor hereunder.

END OF SECTION 01 74 13

SECTION 01 77 00 - CLOSEOUT PROCEDURES FOR SUSTAINABLE DESIGN

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:

1. Compliance with Specification 01 77 10-Final Cleaning
2. Compliance with Specification 01 78 23-Operation and Maintenance Data
3. Compliance with Specification 01 78 36-Warranties and Guarantees
4. Compliance with Specification 01 78 39-Project Record Documents
5. Completion of Asbestos and Lead Free Certification as per Division 1
6. Completion of Lock Out/Tag Out (LOTO) Procedures as per Division 26
7. Final Punch List

1.2 SUBSTANTIAL COMPLETION

A. Preliminary Procedures: Before requesting inspection for determining date of Substantial Completion, complete the following. List items below that are incomplete in request.

1. Prepare a list of items to be completed and corrected (punch list), the value of items on the list, and reasons why the Work is not complete.
2. Advise FAA of pending insurance changeover requirements.
3. Obtain and submit releases permitting FAA unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
4. Prepare and submit Coordination Drawings, Project Record Documents, operation and maintenance manuals, Final Completion construction photographs, damage or settlement surveys, property surveys, and similar final record information.
5. Deliver tools, spare parts, extra materials, and similar items to location designated by FAA. Label with manufacturer's name and model number where applicable.
6. Make final changeover of permanent locks and deliver keys to FAA. Advise FAA's personnel of changeover in security provisions.
7. Complete startup testing of systems.
8. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
9. Advise FAA of changeover in utilities.
10. Submit changeover information related to FAA's occupancy, use, operation, and maintenance.
11. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

B. Inspection: Submit a written request for inspection for Substantial Completion, also referred to as the Contractor Acceptance Inspection (CAI). On receipt of request, COR will either schedule the inspection within fourteen (14) days or notify Contractor of unfulfilled requirements. COR will prepare the Certificate of Substantial Completion after the inspection or will notify Contractor of items, either on Contractor's list or additional items identified by COR, that must be completed or corrected before certificate will be issued. COR will also provide a punch list that will form the basis of requirements for the Final Completion.

1.3 FINAL COMPLETION

A. Preliminary Procedures: Contractor should request final inspection prior to contract completion date. Before requesting final inspection for determining date of Final Completion, complete the following:

1. Submit a Final Application for Payment.
2. Submit certified copy of COR's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by COR. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
3. Submit specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
4. Submit a letter from the airport certifying that work areas located on the airport were left in a satisfactory condition.
5. Perform a final cleaning in accordance with Section 01 74 23 “FINAL CLEANING”.

B. Inspection: Submit a written request for final inspection for acceptance. On receipt of request, COR will either proceed with inspection or notify Contractor of unfulfilled requirements. COR will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

1.4 WARRANTIES

A. Submit warranties in accordance with Section 01 78 36 “WARRANTIES AND GUARANTEES”. Warranty period shall begin on date of Substantial Completion as listed in Certificate of Substantial Completion.

B. Partial Occupancy: Submit properly executed warranties within fifteen (15) days of completion of designated portions of the Work that are completed and occupied or used by FAA during construction period by separate agreement with Contractor.

C. Provide additional copies of each warranty to include in operation and maintenance manuals.

PART 2 – PRODUCTS:

NOT USED

PART 3 – EXECUTION:

NOT USED

END OF SECTION 01 77 00

SECTION 01 77 10 - FINAL CLEANING

PART 1 - GENERAL

1.1 REQUIREMENT INCLUDED

A. Final cleaning of project.

1.2 SUMMARY

A. This section includes administrative and procedural requirements, protections of construction in progress, and for final cleaning at Substantial Completion.

B. Environmental Requirements: Conduct cleaning and waste-disposal operations in compliance with local laws and ordinances. Comply fully with federal and local environmental and antipollution regulations.

C. Do not dispose of volatile wastes, such as mineral spirits, oil, or paint thinner, in storm or sanitary drains.

D. Burning or burying of debris, rubbish, or other waste material on the premises is not permitted.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by the manufacturer or fabricator of the material to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

PART 3 - EXECUTION

3.1 FINAL CLEANING

A. General: Provide final-cleaning operations. Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit of work to the condition expected from a commercial building cleaning and maintenance program. Comply with manufacturer’s instructions.

B. Cleaning Operations: Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for the entire Project or a portion of the Project.

1. Clean the Project Site in areas disturbed by construction activities of rubbish, waste material, litter, and foreign substances.
2. Sweep paved areas broom clean. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
3. Broom and mop clean concrete floors in unoccupied spaces.
4. Remove petrochemical spills, stains, and other foreign deposits.
5. Remove tools, construction equipment, machinery, and surplus material from the site.
6. Vacuum clean carpet and similar soft surfaces, removing debris and excess nap. Shampoo

carpet as directed by COR.

7. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
8. Remove marks, stains, fingerprints, and other soils or other dirt from painted, decorated, and natural finished woodwork and other work.
9. Clean cabinet work removing stains, paint, dirt and dust.
10. Remove spots, plaster, soil and paint from ceramic tile, marble, and other finished materials, and wash or wipe clean.
11. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other substances that are noticeable vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
12. Clean flooring materials thoroughly, including stripping, buffing and waxing. Comply with materials manufacturer's instructions and recommendations.
13. Remove labels that are not permanent labels.
14. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.
15. Wipe surfaces of mechanical and electrical equipment, elevator equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
16. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
17. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency. Replace burned-out bulbs and defective and noisy starters.
18. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
19. Clean ductwork, blowers, and coils of units that were operated during construction.
20. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
21. Leave the Project clean and ready for occupancy.

C. Removal of Protection: Remove temporary protection and facilities installed during construction to protect previously completed installations during the remainder of the construction period.

D. Compliances: Comply with governing regulations and safety standards for cleaning operations. Remove waste materials from the site and dispose of lawfully.

1. Where extra materials of value remain after completion of associated work, they become the FAA's property. Dispose of these materials as directed by the FAA.
2. The Contractor shall not dispose of debris or waste materials on the FAA's property without the prior written approval of the FAA.

END OF SECTION 01 77 10

SECTION 01 78 23 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

1. Operation and maintenance documentation directory.
2. Emergency manuals.
3. Operation manuals for systems, subsystems, and equipment.
4. Maintenance manuals for the care and maintenance of products, materials, and finishes; systems and equipment.
5. Manual for sustainable operations.

1.2 DEFINITIONS

A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.

B. Subsystem: A portion of a system with characteristics similar to a system.

1.3 SUBMITTALS

A. Comply with Section 01 40 10 for submission of Facility Data.

B. Initial Submittal: Submit 2 bound draft copies of each manual and 2 electronic copies in PDF format at least 15 days before requesting inspection for Substantial Completion. Include a complete operation and maintenance directory. COR will return one copy of draft and mark whether general scope and content of manual are acceptable.

C. Final Submittal: Submit two bound copies of each manual and two electronic copies (PDFs) in final form at least 15 days before final inspection. If modifications are required, COR will return one copy with comments within 15 days after final inspection.

1. Correct or modify each manual to comply with COR's comments. Submit two (2) bound copies and two (2) electronic copies of each corrected manual within 15 days of receipt of COR's comments.

1.4 COORDINATION

A. Where operation and maintenance documentation includes information on installations by more than one factory-authorized service representative, assemble and coordinate information furnished by representatives and prepare manuals.

PART 2 - PRODUCTS

2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

A. Organization: Include a section in the directory for each of the following:

1. List of documents.
2. List of systems.
3. List of equipment.
4. Table of contents.

B. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.

C. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.

D. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.

E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

2.2 MANUALS (GENERAL)

A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:

1. Title page.
2. Table of contents.
3. Manual contents.

B. Title Page: Enclose title page in transparent plastic sleeve. Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Address of FAA.
4. Date of submittal.
5. Name, address, and telephone number of Contractor.
6. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

1. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

   a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
   b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.
4. Supplementary Text: Prepared on 8-1/2-by-11-inch white bond paper.
5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

   a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
   b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.3 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:

1. Type of emergency.
2. Emergency instructions.
3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.
8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of FAA's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

D. Emergency Procedures: Include the following, as applicable:

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

2.4 OPERATION MANUALS

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

1. System, subsystem, and equipment descriptions.
2. Performance and design criteria if Contractor is delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

1. Product name and model number.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.5 PRODUCT MAINTENANCE MANUAL

A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

1. Include procedures to follow and required notifications for warranty claims.

2.6 SYSTEMS AND EQUIPMENT MAINTENANCE MANUAL

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:

1. Standard printed maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training videotape, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

G. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.

H. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

1. Include procedures to follow and required notifications for warranty claims.

2.7 MANUAL FOR SUSTAINABLE OPERATIONS

A. Provide all information required to operate building and its systems and components in an environmentally sustainable manner.

1. Arrange manual to be used for training building staff.

2. Include section on Integrated Pest Management (IPM).

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.

B. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by FAA's operating personnel for types of emergencies indicated.

C. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

D. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by FAA's operating personnel.

E. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

F. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation.

1. Do not use original Project Record Documents as part of operation and maintenance manuals.
2. Comply with requirements of newly prepared Record Drawings.

G. Comply with Section 01 77 00 "Closeout Procedures" for schedule for submitting operation and maintenance documentation. Comply with Section 01 40 10 for Facility Data requirements.

END OF SECTION 01 78 23

SECTION 01 78 36 - WARRANTIES AND GUARANTEES

PART 1 - GENERAL

1.1 REQUIREMENTS INCLUDED

A. Preparation and submittal of warranties and guarantees.

1.2 FORM OF WARRANTY

A. Bind in commercial quality 8 ½ x 11 inch three-ring side binders, with hardback, cleanable, plastic covers.

B. Label cover of each binder with typed or printed title `WARRANTIES AND GUARANTEES', with Contract No. and Project Title; name, address and telephone number of Contractor.

C. Table of Contents: Neatly typed, in the sequence of the Table of Contents of the Project Manual, with each item identified with the number and title of the specification section in which specified and the name of the product or work item.

D. Separate each warranty or guaranty with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate typed sheet as necessary. List subcontractor, supplier and manufacturer, with name, address and telephone number of responsible principal.

1.3 PREPARATION OF WARRANTY

A. Obtain warranties and guarantees, executed in duplicate by responsible subcontractors, suppliers and manufacturers, within ten (10) days after completion of the applicable item of work. Date of beginning of time of warranty will be the date of Substantial Completion.

B. Warranties and guarantees shall be made out in the name of, and accrue to the benefit of the Federal Aviation Administration.

1.4 TIME OF WARRANTY

A. Provide warranties prior to final acceptance.

B. For items of work when acceptance is delayed beyond date of Substantial Completion, submit within ten (10) days after acceptance, listing the date of acceptance as the beginning of the warranty or guaranty period.

1.5 EQUIPMENT WARRANTY TAGS AND GUARANTEE LOCAL REPRESENTATIVES

A. The Contractor shall furnish with each guarantee, the name address, and telephone number of the guarantor, the name, address, and telephone number of the guarantor’s representative nearest to the site, who, upon request of the FAA representative, will honor the guarantee during the guaranty period and will provide the service prescribed by the terms of the guarantee. At the time of installation, the Contractor shall tag each item of warranted equipment with a durable, oil and water resistant tag approved by the Contracting Officer’s Representative (COR). Tag shall be attached with copper wire and sprayed with a clear silicone, waterproof coating. Leave the date of acceptance and inspectors signature blank until project is accepted for Substantial Completion. Tag shall show the following information:

B. Equipment warranty tags

1. Type of Equipment
2. Accepted Date
3. Warranted Until
4. Under Contract Number
5. Inspector’s Signature

1.6 QUANTITY

A. Provide three (3) complete copies of warranties and guarantees.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 01 78 36

SECTION 01 78 39 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 REQUIREMENTS INCLUDED

A. This section describes the requirements for the creation and maintenance of “As Built Drawings;” referred to herein as Record Documents.

B. Maintenance of Record Documents.

C. Submittal of Record Documents.

1.2 MAINTENANCE OF DOCUMENTS AND SAMPLES

A. Store Record Documents in Field Office apart from documents used for construction. Provide files, racks and secure storage for Record Documents.

B. Maintain Record Documents in clean, dry and legible conditions. Do not use Record Documents for construction purposes.

C. Keep Record Documents and Samples available for inspection by FAA.

1.3 RECORD DOCUMENTS (AS-BUILT) INFORMATION

A. Record information on a set of full size drawings, provided by FAA.

B. Provide felt tip marking pens, maintaining separate colors for each major system, for recording information.

C. Record information concurrently with construction progress. Do not conceal any work until required information is recorded.

D. Contract Drawings and approved Shop Drawings: Legibly mark each item to record actual construction, including:

1. Measured depths of elements of foundation in relation to finish grade or first floor datum.
2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of construction.
4. Field changes of dimensions and details.
5. Changes made by Addenda, Change Order(s) (if any) and Work Order(s) (if any).
6. Details not on original Contract Drawings.

7. References to related Shop Drawings and Modifications.

E. Specifications: Legibly mark each item to record actual construction, including changes made by Addenda and Change Order.

F. Other Documents: Maintain manufacturer's certification, inspection certifications, field test records, and training documents required by individual Specification Sections.

1.4 SUBMITTALS

A. At Substantial Completion, deliver Record Documents and samples under provision of Section 01 77 00, “CLOSEOUT PROCEDURES”.

B. Provide Portable Document Format (PDF) file of all record drawings on 700+ MB compact disk or other approved electronic media and upload PDF to FAA’s KSN website.

C. Provide CAD produced Record Drawing(s) of all Construction Contract Drawings from as-built information developed during construction.

D. Provide .dgn and .pdf files of same.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 01 78 39

SECTION 01 81 09 - TESTING FOR INDOOR AIR QUALITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions, other Division 1 Specification Sections, and specifications of materials mentioned in this section, apply to this Section.

1.2 SUMMARY

A. General: This section provides requirements for Baseline Indoor Air Quality Testing (IAQT) for maximum indoor pollutant concentrations for acceptance of the facility.

1.3 SUBMITTALS

A. Baseline IAQT: Submit a report for each test site specified for IAQ baseline testing as prescribed herein below and in Division 23, in the section on “Testing, Adjusting, and Balancing.” Report on air concentrations of targeted pollutants identified in Subsection 3.1 of this section.

1.4 SEQUENCING AND SCHEDULING

A. Identify, program, and schedule all IAQT well in advance of construction in a manner to prevent delays to the performance of the work of this Contract in order to perform and complete all testing after the completion of construction activities and prior to occupancy.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

BASELINE IAQ TESTING

A. HVAC System Verification: To assure compliance with recognized standards for indoor air quality including ASHRAE Standard 62.1-2007, the Contractor’s independent testing and balancing agency shall verify the performance of each HVAC system prior to Indoor Air Quality testing, including space temperature and space humidity uniformity, outside air quantity, filter installation, drain pan operation, and any obvious contamination sources.

B. Indoor Air Quality Testing: Upon verification of HVAC system operation, the Contractor shall hire an independent contractor, subject to approval by the Contracting Officer’s Representative, with a minimum of 5 years experience in performing the types of testing specified herein, to test levels of indoor air contaminants for compliance with specified requirements.

1. Conduct baseline IAQ testing using testing protocols consistent with the United States Environmental Protection Agency Compendium of Methods for the Determination of Air Pollutants in Indoor Air.
2. A test plan shall be submitted for the approval of the Contracting Officer’s Representative. The plan shall specify procedures, times, instrumentation, and sampling methods that will be employed.
3. Perform IAQ testing for at least the minimum number of required sampling locations, determined as follows: For each portion of the building served by a separate ventilation system, the number of sampling points shall not be less than one per 25,000 sq. ft., or for each contiguous floor area, whichever is larger, and include areas with the least ventilation as calculated by Ventilation Rate Procedure of ASHRAE Standard 62.1-2004 and greatest presumed source strength as identified by Owner. Collect air samples on three consecutive days and average the results of each three-day test cycle to determine compliance or non-compliance of indoor air quality for each air handling zone tested.

    a. Verify areas to be tested with the Contracting Officer's Representative. Areas with 100 percent outside air ventilation rates such as laboratories are excluded from these testing requirements. The Contracting Officer's Representative is the sole judge of areas exempt from testing.

4. Perform IAQ testing following the completion of all interior construction activities and prior to occupancy. The building shall have all interior finishes installed including, but not limited to, millwork, doors, paint, carpet, and acoustic tiles. Perform testing prior to installation of furniture, workstation components, and casework.
5. Perform IAQ testing within the breathing zone, between 3’–0” and 6’–0” above the finished floor and over a minimum 4-hour period.
6. Collect air samples during normal occupied hours (prior to occupancy) with the building ventilation system starting at the daily normal start times and operated at the minimum outside air flow rate for the occupied mode throughout the duration of the air testing.
7. Sample and record outside air levels of formaldehyde and TVOC contaminants at three outside air locations (as determined by Owner) simultaneously with indoor tests to establish basis of comparison for these contaminant levels by averaging the three outdoor readings for each contaminant.
8. Perform airborne mold and mildew air sampling and speciation with simultaneous indoor and outdoor readings.

    a. Samples are to be collected using a 12 liter-per-minute pump and a 0.45 micron polycarbonate filter, with a 4-hour duration for each sample.
    b. Speciation shall be done with DNA detection using the quantitative polymerase chain reaction (QPCR) method. To ensure that filters are not pre-contaminated with mold, a field blank filter cartridge shall be tested after every eighth sample is tested.

9. Acceptance of respective portions of the building by the Owner is subject to compliance with specified limits of indoor air quality contaminant levels.

C. Indoor air quality shall conform to the following standards and limits:

1. Formaldehyde: <20 microgram/m3 (16.3 ppb)
2. Sum of VOCs: <200 microgram/m3
3. Carbon Monoxide: Not to exceed 9 ppm
4. Other compounds found on the California Office of Environmental Health Hazard Assessment's list of chronic inhalation Reference Exposure Levels (RELs) are not to exceed those levels, as published on: http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html
5. Airborne Mold and Mildew: The species identified in indoor air cannot vary by more than 10 percent from those identified in the exterior samples.

D. Test Reports: Prepare test reports showing the results and location of each test, a summary of the HVAC operating conditions, and a listing of any discrepancies and recommendations for corrective actions, if required.

1. Include certification of test equipment calibration with each test report.

E. For each sampling point where the maximum concentration limits are exceeded, the Contractor is responsible for conducting additional flush-out with outside air and retesting the specific parameter(s) exceeded to indicate the requirements are achieved. Repeat procedure until all requirements have been met. When retesting non-complying building areas, take samples from the same locations as in the first test. Retesting shall be performed at no additional expense to the Owner.

F. For each sampling point where the airborne mold and mildew indoor species distribution varies by more than 10 percent from exterior sampling speciation, Contractor shall identify the source of the mold and/or mildew and remediate with corrective action, then retest in accordance with section 3.1.B above until compliant results are attained.

G. In the event that any non-compliant test results occur, Contractor must provide a written report to the Owner describing the source(s) of the non-compliant condition(s) and the corrective action(s) implemented.

INDEPENDENT MATERIALS TESTING:

A. Materials That Must Be Tested: All materials listed below that are proposed for use on this project shall be tested for permanent, in-place indoor air quality performance in accordance with requirements of these specifications. Results shall be furnished to the Contracting Officer's Representative. Materials meeting the criteria for independent testing are as follows:

1. Field-applied paint systems on appropriate substrate. Paint primers and intermediate coats (if used) should be applied with a typical drying time allowed between coats (not to exceed 7 days).
2. Wall coverings
3. Carpet including manufacturer's recommended adhesive. The carpet will be applied to the appropriate flooring per manufacturer's instructions so that the testing is of the "carpet assembly."
4. Ceiling tile
5. Interior furnishings

6. Any fireproofing material that may be exposed to indoor air, directly or in a plenum, applied to appropriate substrate

B. Materials for Testing: Only test representative samples of actual products selected for use on this project. Tests of products generically and/or technically similar but produced by a manufacturer other than that of the product selected for use on this project are invalid.

C. Materials Testing and Evaluation Protocol: California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," July 2004. Available online: http://www.dhs.ca.gov/ps/deodc/ehlb/iaq/VOCS/

D. Performance Thresholds: All compounds detected that have chronic reference exposure levels listed in the California DHS Standard Practice document shall be analyzed and compared to the allowable concentration levels.

E. Materials Test Reports: Submit test reports to the Contracting Officer's Representative. The report shall include raw emission levels, as well as the calculated resulting concentrations and the assumptions (loading, volume of space, ventilation rates) used to determine those resulting concentrations.

F Product/Material Evaluation: All products/materials shown by testing to comply with emissions limits and other criteria specified in this section will be approved for use on this project subject to compliance with all other specified requirements of the Project Manual. Products/materials shown to exceed specified emission limits shall be discussed, test results interpreted, and a determination made as to alternative product uses or selections.

END OF SECTION 01 81 09

SECTION 02 01 00 – INTERIM LIFE SAFETY MEASURES FOR FACILITIES UNDER CONSTRUCTION

PART 1 - GENERAL

1.1 SUMMARY OF WORK

A. During construction activities, it is likely temporary hazards may be posed due to the work being conducted in the facility. Interim Life Safety Measures (ILSM) are actions that must be taken to compensate for the temporary hazards. This document addressed administrative actions which must be taken to ensure the current level of life safety is maintained at all times and occupants are not subjected to hazardous conditions for even short periods of time.

B. Implementation and Enforcement: Implementation and enforcement of ILSM is the responsibility of all occupants within the building, including employees and construction personnel. However, primary identification of hazards and the actions taken to compensate for temporary hazards are the responsibility of the Contractor. All ILSM are subject to approval by the Contracting Officer's Representative.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION MEETING

A. Prior to commencement of construction, conduct a meeting to inform all FAA maintenance staff of the project scope and duration. This should include, at a minimum, the following:

1. An overview of the construction project.
2. A preliminary schedule for the construction.
3. Discussion of affected fire protection and life safety systems including, active and passive features.
4. Discussions of the effect on daily and emergency operations.
5. Handout of written policies for ILSM for all employees and construction personnel.
6. Demonstration of signs, messages, etc., to be used to identify hazardous conditions and the corresponding ILSM.
7. List of contacts for reporting hazardous conditions.
8. Discussion of anticipated hazards throughout the project and the ILSM for each.

3.2 ACTIVE AND PASSIVE FIRE PROTECTION AND LIFE SAFETY FEATURES

A. Due to the criticality of FAA facilities, most facilities are provided with a number of active and passive fire protection and life safety features. If any of these features are compromised in any way, ILSM shall be instituted immediately. These features include:

1. Fire-resistive construction.
2. Stair ventilation system (stair pressurization or vented vestibule).

3. Fire detection and alarm system.
4. Exit signage.
5. HVAC shutdown.
6. Unlocking security doors.

3.3 SITUATIONS COMPROMISING LIFE SAFETY

A. General concepts of situations which compromise the level of life safety as required by the applicable codes and standards include:

1. Blocked or obstructed exits.
2. Obstructed access for emergency vehicles and personnel.
3. Fire protection system malfunctioning or out of service.
4. Storage of additional combustibles or flammable liquids.
5. Temporary sources of ignition due to construction activities (cutting, welding, etc.).
6. Temporary penetrations in fire-rated walls and partitions (including missing doors).

B. Single Means of Egress: All work shall be conducted in such a way as to not obstruct or compromise the single means of egress from the ATCT.

3.4 SMOKING

A. Smoking shall not be permitted in areas under construction at any time in FAA facilities.

3.5 NOTIFICATION SIGNAGE

A. The Contractor shall provide appropriate signage, in locations approved by the Contracting Officer's Representative, to notify occupants of current activities and ILSM in effect at the facility. The signage shall be verified prior to each construction shift and employee shift. The signage shall indicate the present hazards and the safety measure provided to compensate for the hazards.

3.6 QUALITY CONTROL

A. During construction, the following practices shall be adhered to in addition to those required for specific hazards discussed below:

1. Construction personnel shall check all doors opening into stairs to ensure door hardware is functioning properly. This includes a visual inspection of all doors to ensure the construction has not been compromised and checking all door hardware including latching hardware and self-closing devices to verify proper operation. Any deficient components shall be repaired or replaced immediately.
2. The temporary use of wood chocks or other objects to prop open fire-rated doors shall be permitted as necessary for construction work. At the completion of work for the day, the construction supervisor shall verify all propped doors have been returned to the closed position.

3. The construction supervisor shall inspect the job site a minimum of twice per week to verify all life safety features are present and operational and have not been damaged by construction, including:

    a. Exit signage.
    b. Exits are free of storage or obstructions.
    c. Exit stairs, including treads, landings, handrails, headroom.
    d. Exit illumination.
    e. Emergency lighting (battery-operated).
    f. Evacuation route maps (ensure these are installed and readily visible).

4. If the fire alarm system is not provided with offsite monitoring, provide a telephone with a direct line to the fire department for notification in case of a fire. The Contracting Officer’s Representative shall approve the location of the telephone.
5. Inform the fire department of construction activities in the facility and provide them a copy of written ILSM policies. The Contractor shall regularly update the fire department on the status of construction and ILSM (minimum of once every two weeks).

3.7 OPERATIONAL FIRE ALARM SYSTEM

A. If the facility fire alarm system is not operational, is malfunctioning, or is in a trouble condition due to construction activities, the Contractor shall provide, at a minimum, the following additional ILSM.

B. Inform Fire Department: Inform the fire department of the problems with the facility fire alarm system and inform them of the ILSM being taken to compensate for the deficient system.

C. Trouble Signals: Ensure trouble signals at the main fire alarm control panel and the annunciator panels remain functional until the system is returned to proper function. Trouble signals at panels shall not be bypassed.

D. Magnetic Door Hold-Open Devices: Test magnetic door holders to ensure these devices still operate via the fire alarm system. If door holders do not work, all door holders shall be disabled and shall not be returned to use until the fire alarm system is returned to normal.

E. Facility Inspections: Construction supervisors shall inspect all areas prior to each shift to ensure all active and passive fire protection features are still operational including all fire doors are in closed position and are not propped open, and the sprinkler system is still functional (i.e. valves are in the open position), if applicable.

F. Fire Alarm Inoperable at End of Shift: If the fire alarm system is not operational at the end of the construction shift, provide a temporary, manual switch in the electronics room to activate the stair ventilation system.

3.8 TEMPORARY IGNITION SOURCES

A. When construction activities involve the use of temporary ignition sources ("hot work"), i.e. welding, cutting, plumbers torch, etc., the Contractor shall provide, at a minimum, the following

ILSM. (Note: Additional measures may be required by the Contracting Officer Representative for specific situations.)

1. Inform construction supervisor of hazardous operations.
2. Keep a log of all hot work activities.
3. Provide the appropriate type fire extinguisher to the personnel performing the work (all construction personnel shall be trained in the proper use of fire extinguishers prior to the commencement of work).
4. Disable any fire alarm initiating devices or zones that may be susceptible to a false alarm during the operation. Notify the Contracting Officer's Representative prior to disabling fire alarm devices.
5. Return all fire alarm devices to normal operation at the completion of work. At the end of the shift, all fire alarm devices shall be returned to operational condition regardless of the status of the work.

3.9 STORAGE OF COMBUSTIBLES

A. When construction activities involve the storage of an unusual amount of combustibles and/or combustible liquids within the facility, the Contractor shall provide, at a minimum, the following ILSM. (NOTE: The Specification addressed Contractor storage spaces and other limitations. Additional measures may be required by the Contracting Officer Representative for specific situations.)

1. Submit a written request to the Contracting Officer Representative requesting permission to store materials within the facility. The request shall indicate the proposed location, types and quantities of combustibles, MSDS sheets (if applicable), approximate duration of storage and proposed ILSM. The Contracting Officer's Representative will provide a copy of all requests to the FAA Safety and Environmental Compliance Manager.
2. Provide additional fire extinguishers appropriate for the anticipated hazard.
3. Ensure proper cleaning techniques are utilized in the storage area at the end of each shift. This includes cleaning all dust and waste materials, replacing lids on liquids, cleaning all spills, returning all flammable and combustible liquids to a flammable liquids storage locker.
4. Check throughout the storage area daily for exposed ignition sources. Any exposed ignition sources shall be repaired or removed from the storage area.

END OF SECTION 02 01 00

SECTION 02 03 00 – GENERAL REQUIREMENTS FOR DEMOLITION AND RENOVATION

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

B. AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

1. AHRI Guideline K (2005) Guideline for Containers for Recovered Non-Flammable Fluorocarbon Refrigerants

C. AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

1. ASSE/SAFE A10.6 (2006) Safety Requirements for Demolition Operations

D. U.S. ARMY CORPS OF ENGINEERS (USACE)

1. EM 385-1-1 (2008) Safety and Health Requirements Manual

E. U.S. DEPARTMENT OF DEFENSE (DOD)

1. DOD 4000.25-1-M (2006; Notice 1) Requisitioning and Issue Procedures

F. U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

1. FAA AC 70/7460-1 (Rev K) Obstruction Marking and Lighting

G. U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

1. 40 CFR 61 National Emission Standards for Hazardous Air Pollutants
2. 40 CFR 82 Protection of Stratospheric Ozone
3. 49 CFR 173.301 Shipment of Compressed Gases in Cylinders and Spherical Pressure Vessels

1.2 GENERAL REQUIREMENTS

A. This Section specifies administrative and procedural requirements for demolition and renovation. Refer to other Sections for specific work requirements and limitations applicable to individual parts of the work. Requirements of this Section apply to all disciplines. Refer to specific Sections for other requirements and limitations applicable to the work.

B. Do not begin demolition until authorization is received from the COR. Do not allow accumulations inside or outside the building. The work includes demolition and removal of resulting rubbish and debris. Remove rubbish and debris from Government property daily, unless otherwise directed. Store materials that cannot be removed daily in areas specified by the COR. In the interest of occupational safety and health, perform the work in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections.

C. Protection of Existing Property: Before beginning any demolition work, the Contractor shall carefully survey the site and examine the drawings and specification to determine the extent of the work. The Contractor shall take all necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain in property of the Government, and any damaged items shall be repaired or replaced as approved by the COR at no additional cost to the Government. The Contractor shall carefully coordinate the work of this section with all other work and shall construct and maintain shoring, bracing and supports as required. The Contractor shall ensure that structural elements are not overloaded and shall be responsible for increasing structural supports or adding new supports as may be required as a result of any cutting, removal, or demolition work preformed under this contract.

D. Requirements for Structural Work: Do not cut and patch structural elements in a manner that would reduce their load-carrying capacity or load-deflection ratio.

E. Operational and Safety Limitations: Do not cut and patch operating elements or safety related components in a manner that would result in reducing their capacity to perform as intended, or result in increased maintenance, or decreased operational life or safety.

F. Visual Requirements: Do not cut and patch construction exposed on the exterior or in occupied spaces, in a manner that would, in the COR opinion, reduce the building’s aesthetic qualities or result in visual evidence of cutting and patching. Remove and replace work cut and patched in a visually unsatisfactory manner.

1.3 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1. Demolition Plan

1.4 REGULATORY AND SAFETY REQUIREMENTS

A. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the "Contract Clauses," conform to the safety requirements contained in ASSE/SAFE A10.6.

B. Notifications:

1. General Requirements: Furnish timely notification of demolition projects to the COR in writing 10 working days prior to the commencement of work in accordance with 40 CFR 61, Subpart M.

1.5 DUST AND DEBRIS CONTROL

A. Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution. Vacuum and dust the work area daily.

1.6 PROTECTION

A. Items to Remain in Place: Take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Government. Repair or replace damaged items as approved by the COR. Coordinate the work of this section with all other work indicated. Construct and maintain shoring, bracing, and supports as required. Ensure that structural elements are not overloaded. Increase structural supports or add new supports as may be required because of any cutting, removal, or demolition work performed under this contract. Do not overload structural elements. Provide new supports and reinforcement for existing construction weakened by demolition work. Repairs, reinforcement, or structural replacement require approval by the COR prior to performing such work.

B. Existing Construction Limits and Protection: Do not disturb existing construction beyond the extent indicated or necessary for installation of new construction. Provide temporary shoring and bracing for support of building components to prevent settlement or other movement. Provide protective measures to control accumulation and migration of dust and dirt in all work areas. Remove snow, dust, dirt, and debris from work areas daily.

C. Weather Protection: For portions of the building to remain, protect building interior and materials and equipment from the weather at all times. Where removal of existing roofing is necessary to accomplish work, have materials and workmen ready to provide adequate and temporary covering of exposed areas.

D. Facilities: Protect electrical and mechanical services and utilities. Where removal of existing utilities is specified or indicated on drawings, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities. Floors, roofs, walls, columns, pilasters, and other structural components that are designed and constructed to stand without lateral support or shoring, and are determined to be in stable condition, must remain standing without additional bracing, shoring, or lateral support until demolished or deconstructed, unless directed otherwise by the COR. Ensure that no elements determined to be unstable are left unsupported and place and secure bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

E. Protection of Personnel: Before, during and after the demolition work the Contractor shall continuously evaluate the condition of the structure being demolished or deconstructed and take immediate action to protect all personnel working in and around the project site. No area, section, or component of floors, roofs, walls, columns, pilasters, or other structural element will be allowed to be left standing without sufficient bracing, shoring, or lateral support to prevent collapse or failure while workmen remove debris or perform other work in the immediate area.

1.7 BURNING

A. The use of burning at the project site for the disposal of refuse and debris will not be permitted.

1.8 RELOCATIONS

A. Perform the removal and reinstallation of relocated items as indicated on drawings with workmen skilled in the trades involved. Items to be relocated which are damaged by the Contractor shall be repaired or replaced with new undamaged items as approved by the COR.

1.9 REQUIRED DATA

A. Prepare a Demolition Plan. Include in the plan procedures for careful removal and disposition of materials to be reused, coordination with other work in progress, a disconnection schedule of utility services, a detailed description of methods and equipment to be used for each operation and of the sequence of operations. Include statements affirming Contractor inspection of the existing roof deck and its suitability to perform as a safe working platform or if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the work. Provide procedures for safe conduct of the work in accordance with EM 385-1-1. Plan shall be approved by COR prior to work beginning.

1.10 ENVIRONMENTAL PROTECTION

A. Comply with the Environmental Protection Agency requirements specified.

1.11 USE OF EXPLOSIVES

A. Use of explosives will not be permitted.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Use materials that are identical to existing materials. If identical materials are not available or cannot be used where exposed surfaces are involved, use materials that match existing adjacent surfaces to the fullest extent possible with regard to visual effect. Use materials whose installed performance will equal or surpass that of existing materials **.**

PART 3 - EXECUTION

3.1 INSPECTION

A. Prior to Cutting Existing Surfaces: Examine surfaces to be cut and patched and conditions under which cutting and patching is to be performed. Take corrective action before proceeding, if unsafe or unsatisfactory conditions are encountered.

B. Prior to Proceeding: Meet at the site with parties involved in cutting and patching, including mechanical and electrical trades. Review areas of potential interference and conflict. Coordinate procedures and resolve potential conflicts before proceeding.

3.2 PREPARATION

A. Provide temporary support of work to be cut. Protect existing construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of the Project that might be exposed during cutting and patching operations. Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas. Take all precautions necessary to avoid cutting existing pipe, conduit or ductwork serving the building, but scheduled to be removed or relocated until provisions have been made to bypass them.

3.3 EXISTING FACILITIES TO BE REMOVED

A. GENERAL

1. Existing construction scheduled to be removed for reuse shall be disassembled. Dismantled and removed materials are to be separated, set aside, and prepared as specified, and stored or delivered to a collection point for reuse.

2. Existing Structures:

   a. Demolish structures in a systematic manner from the top of the structure to the ground. Complete demolition work above each level before the supporting members on the lower level are disturbed. Remove structural framing members and lower to ground by means of derricks, platforms hoists, or other suitable methods as approved by the COR.
   b. Locate demolition equipment throughout the structure and remove materials so as to not impose excessive loads to supporting walls, floors, or framing.

3. Cutting and Patching:

   a. Employ skilled workmen to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time and complete without delay.
   b. Cutting: Cut existing construction to provide for installation of other components or performance of other construction activities and the subsequent fitting and patching required to restore surfaces to their original condition. Cut existing construction using methods least likely to damage elements to be retained or adjoining construction. Where possible review proposed procedures with the original installer; comply with original installer's recommendations. In general, where cutting is required use hand or small power tools designed for sawing or grinding, not hammering and chopping. Cut holes and slots neatly to size required with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.

      1) Avoid Marring Existing Surfaces: To avoid marring existing finished surfaces, cut or drill from the exposed or finished side into concealed surfaces.

2) Utility Services: Bypass utility services such as pipe or conduit before cutting, where services are shown or required to be removed, relocated or abandoned. Remove pipe or conduit in walls or partitions that are noted to be removed, unless noted by Contracting Officer Representative to be cut-off. Cap, valve, or plug and seal the remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after bypassing and cutting. Use approved firestopping methods in all fire-rated walls, floors or ceilings.

c. Patch: Patch with durable seams that are as invisible as possible. Comply with specified tolerances. Where feasible, inspect and test patched areas to demonstrate integrity of the installation.
d. Finish Restoration: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
e. Finish Restoration in More than One Area: Where removal of walls or partitions extends one finished area into another, patch and repair floor and wall surfaces in the new space to provide an even surface of uniform color and appearance. Remove existing floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.
f. Smooth Painted Surfaces: Where patching occurs in a smooth painted surface, extend final paint coat over entire area containing the patch, after the patched area has received primer and second coat.
g. Existing Ceilings: Patch, repair or re-hang existing ceilings as necessary to provide an even plane surface of uniform appearance.

4. Items with Unique/Regulated Disposal Requirements: Remove and dispose of items with unique or regulated disposal requirements in the manner dictated by law or in the most environmentally responsible manner.

B. ELECTRICAL

1. Electrical Equipment and Fixtures: Disconnect primary, secondary, control, communication, and signal circuits at the point of attachment to their distribution system.

a. Fixtures: Remove electrical fixtures as indicated on drawings.
b. Electrical Devices: Remove switches, switchgear, transformers, conductors including wire and nonmetallic sheathed and flexible armored cable, regulators, meters, instruments, plates, circuit breakers, panelboards, outlet boxes, and similar items as indicated on drawings.
c. Wiring Ducts or Troughs: Dismantle plug-in ducts and wiring troughs into unit lengths. Remove plug-in or disconnecting devices from the busway.
d. Conduit and Miscellaneous Items: Remove conduit except where embedded in concrete or masonry as indicated on drawings. Consider corroded, bent, or damaged conduit as scrap metal. Sort straight and undamaged lengths of conduit according to size and type. Classify supports, knobs, tubes, cleats, and straps as debris to be removed and disposed.

3.4 DISPOSITION OF MATERIAL

A. Title to Materials: All materials and equipment removed shall become the property of the Contractor and shall be removed from Government property.

B. Reuse of Materials and Equipment: Remove and store materials and equipment indicated to be reused to prevent damage, and reinstall as the work progresses.

C. Disposal of Ozone Depleting Substance (ODS): Class I and Class II ODS are defined in Section, 602(a) and (b), of The Clean Air Act. Prevent discharge of Class I and Class II ODS to the atmosphere. Place recovered ODS in cylinders meeting AHRI Guideline K suitable for the type ODS (filled to no more than 80 percent capacity) and provide appropriate labeling. Recovered ODS shall be removed from Government property and disposed of in accordance with 40 CFR 82. Products, equipment and appliances containing ODS in a sealed, self-contained system (e.g. residential refrigerators and window air conditioners) shall be disposed of in accordance with 40 CFR 82.

1. Special Instructions: No more than one type of ODS is permitted in each container. A warning/hazardous label shall be applied to the containers in accordance with Department of Transportation regulations. All cylinders including but not limited to fire extinguishers, spheres, or canisters containing an ODS shall have a tag with the following information:

   a. Activity name and unit identification code.
   b. Activity point of contact and phone number.
   c. Type of ODS and pounds of ODS contained.
   d. Date of shipment.

2. Fire Suppression Containers: Deactivate fire suppression system cylinders and canisters with electrical charges or initiators prior to shipment. Also, safety caps must be used to cover exposed actuation mechanisms and discharge ports on these special cylinders.

D. Transportation Guidance: Ship all ODS containers in accordance with MIL-STD-129, DLA 4145.25 (also referenced one of the following: Army Regulation 700-68, Naval Supply Instruction 4440.128C, Marine Corps Order 10330.2C, and Air Force Regulation 67-12), 49 CFR 173.301, and DOD 4000.25-1-M.

3.5 DISPOSAL OF REMOVED MATERIALS

A. Regulation of Removed Materials: Dispose of debris, rubbish, scrap, and other materials resulting from removal operations with all applicable federal, state and local regulations as contractually specified.

B. Burning on Government Property: Burning of materials removed from demolished structures will not be permitted on Government property.

C. Removal to Spoil Areas on Government Property: Transport noncombustible materials removed from demolition structures to designated spoil areas on Government property.

D. Removal from Government Property: Transport waste materials removed from demolished structures, from Government property for legal disposal. Dispose of waste soil as directed.

END OF SECTION 02 03 00

SECTION 02 82 15 – THIRD PARTY AIR MONITORING FOR ASBESTOS CONTAINING MATERIALS

PART 1 – GENERAL

1.1 REFERENCE

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. The current version of referenced publications at the time of the bid shall be used. Where conflicts exist between documents, the most stringent requirements shall apply.

A. American National Standards Institute (ANSI)
   1. ANSI Z9.2 (1979; R 1991), Fundamentals Governing the Design and Operation of Local Exhaust Systems
   2. ANSI Z87.1 (1989; Errata; Z87.1a), Occupational and Educational Eye and Face Protection.
   3. ANSI Z88.2 (1992), Respiratory Protection.

B. American Society For Testing and Materials (ASTM)
   1. ASTM E 1368 (1997), Visual Inspection of Asbestos Abatement Projects
   2. ASTM D 2986-95A, Evaluation of Air Assay Media by the Monodisperse DOP (Dioctyl Phthalate) Smoke Test

C. United States Occupational Safety and Health Administration (OSHA)
   1. 29 CFR 1910, Occupational Safety and Health Standards
   2. 29 CFR 1926, Safety and Health Regulations for Construction

D. Compressed Gas Association (CGA)
   1. CGA G-7 (1990), Compressed Air for Human Respiration
   2. CGA G-7.1 (1997), Commodity Specification for Air

E. Environmental Protection Agency (EPA)
   1. EPA 340/1-90-018 (1990), Asbestos/NESHAP Regulated Asbestos Containing Materials Guidance
   2. EPA 340/1-90-019 (1990), Asbestos/NESHAP Adequately Wet Guidance
   3. EPA 560/5-85-024 (1985), Guidance for Controlling Asbestos-Containing Materials in Buildings
   4. EPA 600/4-85-049 (1985), Measuring Airborne Asbestos Following an Abatement Action
   5. 40 CFR 61, National Emission Standards for Hazardous Air Pollutants
   6. 40 CFR 763, Asbestos Hazard Emergency Response Act, Asbestos School Hazard Abatement Reauthorization Act

F. National Institute For Occupational Safety and Health (NIOSH)

1. NIOSH Pub No. 94-113 (1994), NIOSH Manual of Analytical Methods, *4th Edition with First Supplement*

G. Underwriters Laboratories (UL)
   1. UL 586 (1990), High-Efficiency Particulate Air Filter Units

H. ASHRAE
   1. SPC 52.2P, Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size

I. Federal Aviation Administration (FAA)
   1. FAA Order 3910.50, Asbestos
   2. FAA Order 1050.20, Airway Facilities Asbestos Control
   3. Regional Asbestos Control Program Supplement
   4. Article 77, Agreement Between DOT/FAA and the National Air Traffic Controller Association (NATCA)
   5. Article 52, Agreement Between DOT/FAA and the Professional Airways System Specialists (PASS)
   6. Local Asbestos O&M Plan
   7. Local Facility Asbestos Abatement Contingency Plan

J. State and Local Laws/Regulations.
   1. Any applicable state and local regulations that more stringent than the FAA regulations above shall apply to this project.

3.1 DEFINITIONS

A. Adequately Wet: A term as defined in 40 CFR 61, Subpart M and EPA 340/1-90-019 that means to sufficiently mix or penetrate with liquid to prevent the release of particulates. If visible emissions are observed coming from asbestos-containing material (ACM), then that material has not been adequately wetted. However, the absence of visible emissions is not sufficient evidence of being adequately wetted.

B. Asbestos Containing Material: Any material containing more than one percent asbestos. For purposes of these specifications, ACM includes presumed asbestos-containing material (PACM) as defined by 29 CFR 1926.1101.

C. Asbestos Regulated Work Area: An area established to demarcate areas where Class I, II, and III asbestos work is conducted, and any adjoining area where debris and waste from such asbestos work accumulates; and a work area where the airborne concentration of asbestos fibers exceeds, or has a possibility to exceed, the permissible exposure limit.

D. Certified Industrial Hygienist (CIH): An Industrial Hygienist certified in the comprehensive practice of industrial hygiene by the American Board of Industrial Hygiene.

E. Class I Asbestos Work: Activities involving the removal of thermal system insulation (TSI) and surfacing ACM.

F. Class II Asbestos Work: Activities involving the removal of ACM that is not thermal system insulation or surfacing material. This includes, but is not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastic. In some cases, certain “incidental” roofing materials such as mastic, flashing and cements when they are still intact are excluded from Class II asbestos work.

G. Class III Asbestos Work: Repair and maintenance operations where ACM, including TSI and surfacing ACM, is likely to be disturbed. Operations may include drilling, abrading, or cutting a hole, cable pulling, and crawling through tunnels or attics and spaces above the ceiling where ACM or asbestos-containing debris may be disturbed. Removal of small amounts of ACM that would fit into a single glove bag or disposal bag may be classified as a Class III job.

H. Class IV Asbestos Work: Maintenance and custodial construction activities during which employees contact but do not disturb ACM and activities to clean up dust, waste and debris resulting from Class I, II, and III activities. This may include dusting surfaces where ACM waste and debris and accompanying dust exists and cleaning up loose ACM debris from TSI or surfacing ACM following construction.

I. Disturbance: Activities that disrupt the matrix of ACM, crumble or pulverize ACM, or generate visible debris from ACM.

J. Friable ACM: A term as defined in 40 CFR 61, Subpart M and EPA 340/1-90-018 that means any material containing more than 1 percent asbestos as determined using the method specified in 40 CFR 763, Appendix A, Subpart F, Section 1, Polarized Light Microscopy (PLM), that when dry, can be crumbled, pulverized, or reduced to powder by hand pressure.

K. High Efficiency Particulate Air (HEPA) Filter: A filter capable of trapping and retaining at least 99.97 percent of all mono-dispersed particles of 0.3 micrometers or greater in diameter.

L. Industrial Hygienist: A professional qualified by education, training, and experience to anticipate, recognize, evaluate, and develop controls for occupational health hazards.

M. Permissible Exposure Limits: OSHA PELs are worker exposure limits regulating the amount or concentration of a substance in air that shall not be exceeded. (1) An airborne concentration of asbestos of 0.1 fibers per cubic centimeter of air (f/cc) as an eight- (8) hour time weighted average (TWA). (2) An airborne concentration of asbestos of 1.0 f/cc as averaged over a sampling period of thirty (30) minutes (Excursion Limit).

N. Time-Weighted Average (TWA): The TWA is an 8-hour time weighted average of airborne concentration of fibers (longer than 5 micrometers) per cubic centimeter of air that represents the employee's 8-hour workday as determined by Appendix A of 29 CFR 1926.1101.

1.3. GENERAL REQUIREMENTS

The Third Party Air Monitoring Contractor (hereafter referred to as the TPAM Contractor) shall be completely independent from the Abatement Contractor and shall not be an employee of the Abatement Contractor or be an employee or principal of a firm recognized by Federal, state, or local regulations that would constitute a business relationship that would not be considered independent of the Abatement Contractor Scope of Work.

A. The Columbia ATCT is a 7 days per week facility. The TPAM Contractor shall provide all labor, material, and equipment necessary to accomplish the following:

1. Provide professional services to review and comment on the Abatement Contractor’s Asbestos Abatement Plan.

2. If previously untested building components suspected to contain asbestos are observed and located in areas impacted by the abatement work, the TPAM Contractor shall notify the Contracting Officer's Technical Representative (COR) Contracting Officer Representative (COR) who will have the option of presuming the material contains asbestos or directing the TPAM Contractor to collect up to 2 bulk samples of the material. Analysis of bulk samples shall be performed using polarized light microscopy as specified by 40 CFR Part 763, Subpart E, and Appendix C.
3. Develop two air monitoring plans for the asbestos abatement project. One will address area air monitoring inside of the regulated area and in FAA occupied areas outside the regulated area. The other plan will address personal air monitoring for FAA personnel outside the regulated work area. (See Attachments 1 and 2 for Air Monitoring Plans)
4. Conduct asbestos briefings for FAA employees during various phases of the abatement project.
5. Provide 24-hour air monitoring services and accomplish on-site analysis by Phase Contrast Microscopy (PCM) of samples to quantify fiber concentrations.
6. The contractor should provide analysis of air samples by an accredited laboratory Proficiency Analytical Testing (PAT) and/or American Industrial Hygiene Association (AIHA) and National Voluntary Laboratory Accreditation Program (NVLAP) utilizing Transmission Electron Microscopy (TEM) to quantify the airborne asbestos fiber concentration.
7. Provide services to measure and record pressure differentials 24 hours per day.
8. Provide professional services to accomplish full-time site inspection of asbestos removal activities, including daily written reports of such activities.
9. Attend and participate in on-site meetings, such as the preconstruction meeting, as required throughout the project.
10. Provide a "Final Report" to document that abatement activities were performed in compliance with Federal, state, local requirements and the asbestos abatement contract specifications.
11. Provide 24-hour pressure differential alarm monitoring.
12. Provide consultation pertaining to representative personal air monitoring by a CIH in the event the Facility Asbestos Abatement Contingency Plan is implemented.
13. Maintain daily activity logs, which shall be provided to the COR and SECM within 24 hours of request.

B. FAA Furnished Equipment

1. The FAA will not provide office space for use by the TPAM Contractor during the project.

C. Coordination

1. All Coordination between the TPAM Contractor and both the Abatement Contractor and Airway Facilities, shall be exclusively through the COR unless otherwise directed in writing by the Contracting Officer (CO).

D. Schedule of Work

1. Baseline samples will be collected 10 to 30 days prior to abatement. No activities will be allowed to proceed if baseline samples analyzed by PCM indicate fiber concentrations greater than 0.025 f/cc. If the results are greater than 0.025 f/cc, re-sampling and establishment of a new baseline will take place following re-cleaning by the abatement contractor. If baseline concentrations less than 0.025 f/cc cannot be achieved, the COR will obtain justification for approval by the FAA headquarters' CIH. The COR will be responsible for identifying the schedule for baseline samples to be collected.
2. All set-up work (e.g. enclosure construction, pre-cleaning) by the Abatement Contractor shall take place during off-hours between 11:00PM and 5:00AM. During abatement, all asbestos abatement shall take place after all enclosures have been erected and between the hours of 11:00PM and 5:00AM.
3. Analysis. Approximately one (1) additional hour 5:00AM to 6:00AM will be necessary to complete analysis of end of abatement shift samples and the daily log report.
4. Around the clock monitoring. Approximately one (1) additional hour prior to the work shift 10:00PM to 11:00PM] will be necessary to complete analysis of off-work shift samples. Results shall be turned over to the COR prior to commencement of daily abatement activities.
5. Weekend/holiday. Samples will be collected and analyzed on-site in maximum of 12-hour cycles.

E. Safe Working Condition

1. All FAA and OSHA safety regulations must be observed and enforced at all times during the project to protect both FAA and TPAM Contractor employees from injury or illness.

F. Facility Security Requirements

1. The ATCT is under security at all times. All critical areas (e.g. air traffic control towers) are controlled by means of a personal identification system. All personnel entering the facility will require a visitor badge, which must be worn while on the premises. Further instructions regarding security requirements will be furnished at the time the badges are issued. All Contractors and their employees will be required to sign site entry/exit log on a daily basis.
2. Sanitary Facilities. Rest rooms are located throughout the facility and will be made available for use by the TPAM Contractor's employees.
3. Cafeteria and/or Break Areas. Use of FAA cafeteria and break areas will be allowed.
4. Housekeeping. The TPAM Contractor shall keep the working area in a clean and proper condition. All rubbish and waste resulting from execution of the TPAM Contractor's work shall be removed at the end of each shift. Asbestos contaminated sampling waste shall be disposed of properly and will be combined with the waste generated by the Abatement Contractor.
5. Cleanup. Upon completion of the work, the TPAM Contractor shall remove his/her equipment, and unused supplies and materials.

1.4. DESCRIPTION OF WORK

The areas of Asbestos Containing Materials are listed in the drawings.

1.5. REQUIREMENTS

A. Medical Surveillance Examinations

1. Medical requirements shall conform to 29 CFR 1926.1101.

B. Exposure Data

1. The TPAM Contractor shall maintain complete and accurate employee exposure data on file at the work site as required by 29 CFR 1910.1020 and 29 CFR 1926.1101.

C. Certification, Accreditation and Training
NOTE: The asbestos training requirements have been delegated to EPA agreement states. Some states have adopted more stringent training requirements. Edit this paragraph in accordance with the most stringent requirement. Items referenced in brackets are subject to change based on local requirements.

1. Certification. All work under this contract shall be performed under the direction of an individual certified in the comprehensive practice of industrial hygiene by the American Board of Industrial Hygiene.

2. Accreditation. The independent laboratory and TPAM Contractor on-site analysts shall meet the requirements of the American Industrial Hygiene Association (AIHA), the Asbestos Analyst Registry (AAR), Proficiency Analytical Testing (PAT) Program, and the National Institute of Standards and Technology (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) as applicable for the type of analysis performed.

3. Training. All persons executing the duties under this contract shall have completed appropriate EPA Model Accreditation Program (MAP) training and required annual refresher courses as appropriate for the duties that will be performed under this contract. Updates will be done as required.

D. The TPAM Contractor’s CIH shall have completed an EPA MAP Asbestos Project Designer Training course.

E. The TPAM Contractor’s designated on-site oversight person shall meet the requirements of a Competent Person as outlined in 29 CFR 1926.1101. This person shall be licensed in the state or possess current EPA MAP certification as a Project Monitor and/or Contractor/Supervisor.

F. PCM air sample analysts shall have completed NIOSH 582 or equivalent training.

G. Personnel who collect bulk samples of suspect ACM shall have completed an EPA MAP Asbestos Inspector Training course.

H. Related Work Experience:

1. The TPAM Contractor’s CIH shall possess at least 3 years of experience in the asbestos abatement field.

2. The TPAM Contractor’s designated on-site oversight person shall possess at least 2 years of experience in the asbestos abatement field.

3. Respiratory Protection Program

   a. The TPAM Contractor's CIH shall establish in writing, and implement a respiratory protection program in accordance with 29 CFR 1926.1101, 29 CFR 1910.134, ANSI Z88.2, CGA G-7 and CGA G-7.1.

4. Hazard Communication Program

   a. A written hazard communication program shall be established and implemented in accordance with 29 CFR Section 1926.59.

5. Site Specific Hazards

   a. NOTE: Provide TPAM Contractor with requirements for addressing site-specific hazards that may be encountered with this work.

I. Permits, Licenses and Notifications

   a. NOTE: Verify whether the city, county, state, and/or USEPA has jurisdiction, and whether licenses or permits are required.

J. Insurance

The Contractor shall purchase and maintain the following insurance coverage, with the stated minimum limits:

Type of Coverage	Minimum Limit
Automobile Liability	$1 million per occurrence for bodily injury
	$50,000 per occurrence for property damage
Worker's Compensation	$1 million per occurrence
Errors & Omissions	$1 million per occurrence
Professional Liability	$1 million per occurrence

The policies evidencing required insurance shall be written on a comprehensive form of policy listing the FAA as the certificate holder. The policies shall also contain an endorsement to the effect that any cancellation or any material change adversely affecting the FAA's interest shall not be effective for such period as the laws of South Carolina allow or until 30 days after the insurer or the Contractor gives written notice to the CO, whichever period is longer. Each policy shall include a provision that the FAA will be notified at least 30 days in advance of the effective date of any reduction in coverage or cancellation.

K. Materials and Equipment

1. General: Unless otherwise stated herein, the TPAM Contractor shall provide all materials and equipment necessary to perform the work. This may include, but not be limited to: electrical cords, ground fault circuit interrupters, first aid kits, logbooks, log forms, markers with indelible ink, etc.

2. Air Monitoring: Air monitoring equipment furnished shall include, but not be limited to, high and low volume pumps, calibration equipment, chemical agents, quick fix and slides, and microscope with accessories. Upon approval of the Abatement Contractor's Asbestos Abatement Plan, the TPAM Contractor shall prepare two Air Monitoring Plans for the performance of all work required under this contract. The Area Air Monitoring Plan will include, at a minimum, the specifics of the 24 hours per day/7 days per week area air sampling plan, baseline sampling, and clearance sampling. The Personal Air Monitoring Plan

shall address the implementation of the Facility Asbestos Abatement Contingency Plan at any time during the abatement project.

L. Pressure Differential Recordings

1. The TPAM Contractor shall furnish all equipment and personnel necessary to provide continuous, 24 hour/day, pressure differential monitoring in order to insure the Abatement Contractor’s conformity with the requirements of the abatement contract. The TPAM Contractor’s differential monitoring equipment will be calibrated and certified to the manufacturer's specification prior to the start of work. It shall be the TPAM Contractor’s responsibility to routinely check their monitors at the beginning and end of each working day and twice per day during the removal activity. Pressure differential shall be remotely monitored with a 60-second time delay during removal activity. The COR must be notified should pressure differentials be less than 0.02 inches of water or above 0.05 inches of water. Pressure differentials greater than 0.05 inches of water must be approved by the COR and TPAM Contractor’s CIH. At no time shall pressure differential exceed 0.1 inches of water. Recordings shall be documented in the Daily Log.

2. Equipment. The monitors provided shall possess the following minimum features:

   a. High and low limit alarm set points

   b. Audible and visual alarm system

   c. Alarm delay feature

   d. LCD display showing inches of water column

   e. Strip Chart Recorder (must include date and time)

   f. + 1 % accuracy

3. The pressure differential monitoring equipment shall have the capacity to be remotely monitored to the FAA and Maintenance Control Center (MCC). The location will be coordinated with the facility. The purpose of the alarm is to alert FAA personnel who will page the TPAM Contractor should an immediate assessment of the regulated work area be necessary.

M. Rental Equipment

If rental equipment is to be used, written notification shall be provided by the TPAM Contractor to the rental agency concerning the intended use of the equipment, the possibility of asbestos contamination of the equipment, and the steps that will be taken to decontaminate such equipment. A written acceptance of the terms of the TPAM Contractor's notification shall be obtained from the rental agency.

1.6. SUBMITTALS

A. Medical Examinations

1. Provide the physician’s written opinions documenting completion of most recent medical examinations that verify the ability of the TPAM Contractor’s employee’s to work under the anticipated site conditions. This information must be provided to the COR at least 30 days prior to the start of work.

B. Exposure Data

1. There are no submittals required for exposure data.

C. Certification, Accreditation and Training

1. Certification. Provide proof of current certification of the Certified Industrial Hygienist who will direct all work under this contract to the COR with the bid. The CIH shall be an accredited Asbestos Project Designer.

2. Accreditation

a. Provide proof of successful participation in the last four (4) PAT program rounds by the parent lab of persons who will be performing the air monitoring services and fiber analysis to the COR with the bid package.

b. The TPAM Contractor and independent laboratory shall provide proof of accreditation that all laboratories and onsite analysts meet the AIHA, the Asbestos Analyst Registry, PAT Program, NVLAP, and NIOSH 582 or equivalent with the bid package. Lack of such evidence will indicate failure to meet the requirements of this specification.

3. Training

D. Provide proof of current EPA training of all TPAM Contractor personnel executing the duties established by this contract to the COR at least 30 days prior to the start of work.

E. Provide proof that the oversight person meets the requirements of a “Competent Person” as outlined in 29 CFR 1926.1101 paragraph (b); has at least three years related experience, and is licensed in the state or possesses current EPA accreditation as a Contractor/Supervisor under AHERA and/or Project Monitor under state requirements to the COR at least 30 days prior to the start of work.

F. Related Work Experience for CIH and Industrial Hygienists/Industrial Hygiene Technicians. Submit resumes documenting work experience as required by paragraph 1.5.C to the CO with the bid package.

G. Respiratory Protection Program

1. Provide a copy of the TPAM Contractor’s Respiratory Protection Program and documentation of respirator fit-tests to the COR at least 30 days prior to the start of work.

H. Hazard Communication Program

1. Provide a copy of the TPAM Contractor’s Hazard Communication Plan and MSDSs for all hazardous chemicals to be used onsite to the COR at least 30 days prior to the start of work.

I. Site Specific Hazards

1. Provide a Site Safety Plan to address the hazards provided in paragraph 1.5.F to the COR at least 30 days prior to the start of work.

J. Permits, Licenses and Notifications

1. Provide necessary Federal, State, regional and local licenses, as required to perform environmental monitoring services to the COR at least 30 days prior to the start of work.

K. Insurance

1. Provide original certificates of insurance to the CO with the bid.

L. Materials and Equipment

M. General. Provide a list of all equipment to be brought on site along with manufacturer's specifications to the COR at least 30 days prior to the start of work.

N. Air Monitoring Equipment. Provide a list of all air monitoring equipment to be brought on site along with manufacturer's specifications to the COR at least 30 days prior to the start of work.

O. Air Monitoring

1. Area and Personal Air Monitoring Plans. Upon approval of the Abatement Contractor's Asbestos Abatement Plan, the TPAM Contractor shall submit two Air Monitoring Plans for the performance of all work required under this section to the COR at least 10 days prior to the start of work.
2. Air Monitoring Results. Typically, verbal air sampling results will be provided to the COR within 1 hour from the time of analysis and written results will be provided within 24 hours. Results exceeding the specified stop work levels must be reported verbally within one hour of analysis with written results posted the next day. Final clearance air monitoring results shall be submitted within 3 days of collection of the samples.

P. Pressure Differential Recordings

1. Copies of strip chart recordings shall be provided to the COR daily.

Q. Rental Equipment

A copy of the written acceptance of the terms of the TPAM Contractor's notification to the rental agency shall be submitted to the COR at least 10 days prior to the start of work.

PART 2.0 – EXECUTION.

2.1. <u>INSPECTIONS</u>

A. Preliminary.

The TPAM Contractor shall thoroughly inspect the area where abatement will be performed prior to the start of work. The purpose of this preliminary inspection shall be to develop air-monitoring strategies and review the feasibility of the Abatement Contractor's Asbestos Abatement Plan with respect to actual site conditions.

B. Daily.

The TPAM Contractor shall conduct daily inspections of the Abatement Contractor's activities inside and outside of the asbestos regulated work area during each phase of abatement work. Such inspections shall be performed at least two times per shift inside of the asbestos regulated work area. Pre-cleaning, set-up work, abatement work practices, barrier/enclosure integrity, operation of negative air filtration units, and any other activities that may impact the intent of the asbestos abatement specifications or the Asbestos Abatement Plan shall be assessed. Smoke testing of enclosures shall be performed and documented prior to the start of abatement work. If activities or situations are observed that do not conform to the intent of the asbestos abatement specifications and/or Federal, State, or local regulations, the TPAM Contractor shall immediately notify the COR that corrective action is required.

C. Final Inspection.

1. Upon completion of abatement work and initial cleaning by the Abatement Contractor, the TPAM Contractor and COR shall conduct a visual inspection of the asbestos regulated work area in preparation for a final cleaning. Following approval of the initial cleaning by the COR, the Abatement Contractor will perform a final cleaning of the work area. After final cleaning has been completed, the TPAM Contractor's onsite oversight person and COR shall conduct a final visual inspection of the cleaned asbestos regulated work area and complete the Final Cleaning and Visual Inspection form as specified by ASTM E 1368 (1997).

2.2. REVIEW OF ASBESTOS ABATEMENT PLAN

Services required in this contract include the review of the Abatement Contractor's Asbestos Abatement Plan by the TPAM Contractor's CIH. The TPAM Contractor shall review the Plan and provide a written approval or disapproval signed by a CIH. When the TPAM Contractor disapproves the Plan, the reviewer shall reference the appropriate regulation or specification section under which the Plan fails to comply and recommend amendments to the Plan.

2.3. BRIEFINGS

A. The TPAM Contractor's CIH shall conduct four (4), 60-minute briefings at the Facility to inform the occupants of work places adjoining the asbestos control areas about various aspects of the project including:

1. Purpose and scope of the project.
2. Location of the work, regulated areas, and alternate routes for foot traffic and fire escape.
3. Health aspects of asbestos exposure.
4. OSHA Asbestos Standards.
5. Protective measures that will be utilized.
6. Monitoring program to determine level of airborne asbestos and differential pressures.
7. Inspection procedures to verify asbestos removal and the Abatement Contractor's compliance with safety precautions.
8. Condition/situations that warrant notification to the COR for potential work stoppage.

B. Briefings shall be scheduled once per day, on consecutive days. They shall be conducted approximately 10 days prior to the start of any asbestos related construction activity.

C. On-site Meeting: The TPAM Contractor shall attend, and participate in on-site construction meetings such as the pre-construction meeting throughout the duration of the project. The asbestos portion of each meeting will be summarized and documented in the project log.

2.4. MONITORING NEGATIVE PRESSURE

A. The TPAM Contractor shall monitor, document, and report to the COR that the containment has been under negative pressure for a constant period of no less than 24 hours before abatement starts. If the containment is found to be unacceptable, the TPAM Contractor shall provide recommendations for corrective action to the COR.

B. The TPAM Contractor shall immediately notify the COR of any and all alarm conditions (as established in the Facility Asbestos Abatement Contingency Plan). The TPAM Contractor shall conduct inspections in the containment and perform negative pressure differential monitoring at least 2 times per shift. These inspections and pressure differential readings will be noted in the daily logbook.

C. The strip charts shall be set up in a way that they are "time traceable", i.e. while looking at a strip chart, one will be able to instantaneously determine the date and the exact time of day when a given pressure reading was recorded.

D. During off hours, the Environmental Monitoring Contractor shall verbally respond after 30 minutes of being contacted by the FAA and shall be onsite to perform an assessment not later than 60 minutes from the time of the initial page.

2.5. STOP WORK The TPAM Contractor shall immediately notify the COR of the following conditions. This will be sufficient evidence for the COR to direct the Abatement Contractor to stop work and take corrective action as outlined in the Facility Asbestos Abatement Contingency Plan.

A. If air sampling and analysis conducted in accordance with these specifications and the TPAM Contractor's approved Area Air Monitoring Plan indicates airborne fiber concentrations of 0.02 f/cc above baseline or greater outside of the asbestos regulated work area.

B. If the TPAM Contractor measures pressure differentials less than 0.02 inches of water or greater than 0.05 inches of water inside the containment of the asbestos work area.

C. Work or conditions found to be in violation of this specification or applicable regulations. This includes, but is not limited to, puncture or collapse of containment barriers, electrical power loss, ground-fault circuit interrupter failure, equipment failure, dry removal of ACM, and visible emission from the asbestos regulated work area.

D. Any other condition that may adversely impact or disrupt flying operations or working conditions at the facility.

2.6. AIR SAMPLING

Sampling and analysis of airborne concentrations of asbestos fibers shall be performed in accordance with the TPAM Contractor's approved air monitoring plans and as specified herein. For area sampling during asbestos abatement work, NIOSH Pub No. 84-100 Method 7400 (PCM) with optional confirmation of results by NIOSH Pub No. 84-100 Method 7402 Transmission Electron Microscopy (TEM)] shall be used. All area sampling will be conducted at a sufficient flow rate and time to collect a sample volume necessary to establish the limit of detection of the method used at 0.01 f/cc. The sampling and analytical method used for final clearance air sampling will be the mandatory EPA TEM Method specified at 40 CFR 763. For personal sampling required by 29 CFR 1926.1101, NIOSH Method 7400 or equivalent shall be used for sampling and Phase Contract Microscopy (PCM) analysis. Asbestos fiber concentration confirmation of the total fiber concentration results of samples collected and analyzed by NIOSH Method 7400 may be conducted. In cases where confirmation is required, analysis shall be carried out using transmission electron microscopy in accordance with NIOSH Method 7402. When such confirmation is conducted, it shall be from the same sample filter used for the NIOSH Method 7400 PCM analysis. Prior approval of the FAA is required for confirmatory analysis. All confirmatory analysis shall be at the FAA's expense. The FAA may duplicate monitoring at the discretion of the Contracting Officer. The

Environmental Monitoring Contractor shall archive sampling cassettes for the duration of the project plus 6 months.

2.7. SAMPLING PRIOR TO ASBESTOS WORK (BASELINE SAMPLES)

The baseline air sampling shall be established 1-30 days prior to the masking and sealing operations for each abatement area site. Pre-abatement air samples shall be collected at a minimum of five locations. These locations are: Outside the building, inside the building, but outside the abatement area and inside each abatement area. One sample shall be collected for each 10,000 cubic feet (ft^3) of total area in the abatement work area. One additional sample shall be collected for each 5,000 ft^3 of area over 10,000 ft^3. Baseline samples will be collected from adjacent areas per the Facility Asbestos Abatement Contingency Plan. The samples shall be analyzed immediately using NIOSH Method 7400 (PCM). If any of the samples result in fiber concentration greater than 0.025 f/cc, asbestos fiber concentration shall be confirmed using NIOSH Method 7402 (TEM) at FAA expense.

2.8. SAMPLING DURING ASBESTOS ABATEMENT WORK AND OFF-SHIFT HOURS

The TPAM Contractor shall provide area sampling as indicated in 29 CFR 1926.1101, state and local requirements, and in accordance with the approved air monitoring plans. Area sampling shall be conducted at least once every shift, close to the work in the containment area, outside the clean room entrance to the containment area, (outside air lock for mini and modified containment areas), inside the clean room (inside the air lock for mini and modified containment areas), outside the load-out unit exit, if used, and at an exhaust discharge point of the local exhaust system. In areas where the construction of a containment area is not required, after initial time weighted average (TWA) airborne fiber concentrations are established, and provided the same type of work is being performed, the PCM sampling shall be conducted at the boundary of the asbestos regulated work area in such locations and frequency, as stated in the approved air monitoring plan.

2.9. SAMPLING AFTER FINAL CLEAN-UP (FINAL CLEARANCE SAMPLING)

The following clearance section shall be incorporated into asbestos abatement project specification. This section shall remain in effect until the FAA National Policy is coordinated and adopted.

A. Final Cleaning and Inspections

Typically, final clearance air monitoring shall not begin until 24 hours after completion of final cleaning. In cases where time is critical, the discretion of the CIH and COR shall be allowed. The collection of samples before adequate drying of the lockdown may result in invalid clearance sample results.

Prior to conducting final air clearance monitoring, the TPAM Contractor and the COR shall conduct a final visual inspection of the Abatement Contractor's final cleanup of the abated asbestos regulated work area. After COR acceptance of the final cleaning, the COR will direct the Abatement Contractor to apply the lockdown encapsulant. Final clearance air monitoring shall not begin until 24 hours after COR acceptance of lockdown encapsulant application. The TPAM Contractor will provide area sampling of airborne fibers using aggressive air sampling techniques described in 40 CFR Part 763, Appendix A to Subpart E. The collected samples shall be analyzed using Transmission Electron Microscopy (TEM) by a laboratory that participates in the National Institute of Standards and Technology (NIST) National Voluntary Laboratory Accreditation Program (NVLAP).

B. Final Clearance Criteria

The final clearance air samples shall be collected under aggressive sampling conditions as defined in 40 CFR Part 763, Appendix A to Subpart E. A minimum of 5 area air samples shall be collected inside each contiguous abatement work area. A minimum of 5 area air samples per ambient area positioned at locations representative of the air entering the abatement site shall be collected. Two (2) field blanks are to be taken by removing the cap for not more than 30 seconds and replacing it at the time of sampling before sampling is initiated at the entrance to each abatement area and at one of the ambient sites. A sealed blank is to be carried with each sample set. The work area shall be considered clean when all 5 inside samples are at or below 0.005 asbestos structures per cubic centimeter (St/cc) of air. No averaging of results shall be used. The recommended volume of air for each sample shall be 1800 liters of air. The final clearance results shall also indicate that each sample is at or below 70 structures per square millimeter (St/mm^2).

C. Air Clearance Failure

The Asbestos Abatement Contractor shall repeat final cleaning procedures at no additional cost to the Government if any sample exceed the clearance criteria in 2.9.B. Failure to meet final clearance criteria for any individual sample, will require the Asbestos Abatement Contractor to pay all cost associated with additional cleaning requirements and the cost of all additional sampling and TEM analysis. If one sample fails the final clearance criteria, the complete set of samples identified in paragraph 2.9.B shall be repeated.

END OF SECTION 02 82 15

ATTACHMENT 1: MODEL AREA AIR SAMPLING PLAN

- The TPAM Contractor shall conduct baseline sampling sufficient to document conditions prior to abatement in each room/area to be abated and in all perimeter areas that will be included during off-shift monitoring periods. At least one baseline sample shall be collected for each 10,000 ft^3 of total area inside of each area that will be abated.

- The TPAM Contractor's work hours will be coordinated with the COR. During this time, samples will be collected as follows and the results reported to the appropriate personnel within one hour after analysis: Area sampling shall be conducted at least once every shift in the following locations: close to the work in the containment area, outside the clean room entrance to the containment area, (outside air lock for mini and modified containment areas), inside the clean room (inside the air lock for mini and modified containment areas), outside the load-out unit exit, if used, and at the exhaust discharge point of the local exhaust system. If more than one discharge point for the local exhaust ventilation system exists, each discharge point will be sampled at least once during each day that asbestos abatement activities are conducted.

- Off-shift sampling shall be conducted as follows: One hour after completion of the abatement work shift all area air pumps (minimum of eight) will be set up and allowed to run until one hour prior to the beginning of the next shift. No more than 3,000 liters of air will be collected for any off-shift samples. If sampling is to take place in a dusty area, the flow rate will be reduced by a sufficient amount to ensure that the samples do not become overloaded. Analysis of off-shift samples will be by NIOSH Method 7400 (PCM).

- During periods of no Abatement Contractor work activity, for example weekends, sampling will be conducted in a maximum of 12-hour cycles. For example the TPAM Contractor will arrive on-site at 0600 and place samples. Twelve hours later, at 1800, the TPAM Contractor will return to collect the samples and place new samples to be collected at 0600 the following day. The shift will be 1800 to 2000 and 0600 to 0800 on these days.

- Clearance sampling shall be conducted in accordance with EPA Publication 560/5-85-024. A minimum of five samples will be collected inside of the abatement area and five samples collected outside of the abatement area following Class I and II projects and analyzed using the EPA TEM method specified in 40 CFR Part 763. Decontamination of the abated asbestos regulated work area is considered complete when the arithmetic mean concentration of the minimum of 5 inside samples is less than or equal to 70 structures per square millimeter (70 S/mm^2). When the arithmetic mean is greater than 70 S/mm^2, the 3 blank samples shall be analyzed. If the three blank samples are greater than 70 S/mm^2, re-sampling is required. If less than 70 S/mm^2, the five outside samples shall be analyzed and a Z-test analysis performed. When the Z-test results are less than 1.65, the decontamination can be considered complete. If the Z-test results are more than 1.65, the abatement is incomplete and re-cleaning is required.

WEEKDAY/ CONTRACTOR'S WORK DAY SCHEDULE

Start Time	Location	Flow Rate (liters/minute)	Stop Time	Volume (liters)	Results Reported

WEEKEND/ NON-CONTRACTOR WORK DAYS

Start Time	Location	Flow Rate (liters/minute)	Stop Time	Volume (liters)	Results Reported

ATTACHMENT 2: MODEL PERSONAL AIR SAMPLING PLAN

In the event of perimeter air sample results at or above 0.02 fibers per cubic centimeter of air (f/cc) above baseline or if it is expected that the permissible exposure limit (PEL) of 0.1 f/cc will be reached or exceeded, the TPAM Contractor will notify FAA employees occupying the affected area. The TPAM Contractor will notify the COR when fiber counts exceed 0.02 f/cc above baseline. Notification will be performed in accordance with the Facility Asbestos Abatement Contingency Plan, Figure 1 Emergency Response Flow Chart. If perimeter air sampling results exceed 0.1 f/cc, the Facility Asbestos Abatement Contingency Plan and the personal monitoring program described below will be implemented:

Area Of The Facility	Number Of Personal Samples As Representive

The first personal sample will be a 30-minute excursion sample and remaining samples may be 30-minute excursion or representative of the full shift exposure of FAA employees. The personnel chosen for monitoring will be identified based on the following criteria: 1) The personnel most at risk of exposure by their proximity to released asbestos; 2) The personnel most likely to remain in the control room the longest; 3) The personnel who are most likely to stay in one area to work; and 4) The personnel willing to volunteer for the suggested sampling.

The TPAM Contractor will be responsible for the maintenance, calibration, and proper use of personal air monitoring equipment and adhering to the National Institute for Occupational Safety and Health (NIOSH) 7400 Method or equivalent for phase contrast microscopy (PCM). TPAM Contractor PCM analysts will be listed in the American Industrial Hygiene Association’s Asbestos Analytical Registry. Any transmission electron microscopy (TEM) analysis will utilize the NIOSH 7402 Method and be performed by a laboratory accredited by the American Industrial Hygiene Association.

Samples will be collected per OSHA technical field manual protocols.

SECTION 02 82 33 - REMOVAL AND DISPOSAL OF ASBESTOS CONTAINING MATERIALS

PART 1 GENERAL

1.2 DESCRIPTION OF WORK

The work covered by this section includes possible handling of friable and nonfriable materials containing asbestos which may be encountered during removal and demolition operations and the incidental procedures and equipment required to protect workers and occupants of the building or area, or both, from contact with airborne asbestos fibers. The work also includes the disposal of any removed asbestos-containing materials. Perform work in accordance with 29 CFR 1926.1101; 40 CFR 61, Subpart A; 40 CFR 61, Subpart M; and the requirements specified herein. The potential asbestos work will be included in the demolition of the existing ATCT. Any ACM demolition will be included in the demolition of the tower. Appendices include previous reports and building plan information. Based on included reports the previously identified ACM may already have been removed.

1.2.1 Asbestos Survey

Previous asbestos Survey's were conducted in the contract work area(s) to identify the presence of asbestos containing materials as described in 1.2 above. The data collected is contained in the ASBESTOS SURVEY REPORT.

1.2.2 Unidentified ACM

If ACM not identified by the ASBESTOS SURVEY REPORTS, the drawings or the specifications is encountered, the Contractor shall stop work and immediately notify the Resident Engineer. Upon direction from the Resident Engineer, the Contractor may be required to conduct sampling and testing of these suspect materials in accordance with the Industrial Hygienist's recommended procedures. Payment for this additional work will be as per the contract clauses.

1.3 DEFINITIONS

1.3.1 Action level

An airborne concentration of asbestos of 0.1 fiber (longer than 5 micrometers) per cubic centimeter (f/cc) of air calculated as an eight-(8)-hour time weighted-average (TWA).

1.3.2 Aggressive method

Removal or disturbance of building material by sanding, abrading, grinding or other method that breaks, crumbles, or disintegrates intact Asbestos Containing Material (ACM).

1.3.3 Amended Water

Water containing a wetting agent or surfactant.

1.3.4 Area Monitoring

Sampling of asbestos fiber concentrations within the regulated area and outside the regulated area which is representative of the airborne concentrations of asbestos fibers which may reach the breathing zone.

1.3.5 Asbestos

Includes chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these minerals that has been chemically treated and/or altered. For purposes of this standard, "asbestos" includes PACM, as defined below.

1.3.6 Asbestos Abatement Contractor

A business entity certified, licensed, or accredited by the state in which a response action involving asbestos-containing building material that is friable, or expected to become friable during the response action, is undertaken.

1.3.7 Asbestos Containing Material (ACM)

Material composed of asbestos of any type and in an amount greater than 1 percent by weight, either alone or mixed with other fibrous or nonfibrous materials.

1.3.8 Asbestos Fibers

Asbestos fibers having length-to-diameter ratio of at least 3 to 1 and 5 micrometers or longer as counted in the NIOSH Method 7400 or Method 7402 procedure using either phase contrast light microscopy (PCM) or transmission electronic microscopy (TEM).

1.3.9 Asbestos Permissible Exposure Limit (PEL)

Exposure to an airborne concentration of asbestos fibers not to exceed 0.1 fiber per cubic centimeter of air as an eight-(8)-hour time weighted average (TWA).

1.3.10 Authorized Person

Any person authorized and required by work duties to be present in regulated areas.

1.3.11 Breathing Zone

A hemisphere forward of the shoulders with a radius of approximately 6 inches to 9 inches.

1.3.12 Category I Nonfriable ACM

Category I Nonfriable ACM includes asbestos-containing packing, gaskets, resilient floor covering, and asphalt roofing products.

1.3.13 Category II Nonfriable ACM

Category II Nonfriable ACM includes any asbestos-containing material not included in Category I that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.

1.3.14 Certified Industrial Hygienist (CIH)

One certified in the comprehensive practice of industrial hygiene by the American Board of Industrial Hygiene.

1.3.15 Class I Asbestos Work

Activities involving the removal of Thermal System Insulation (TSI) and surfacing ACM and PACM.

1.3.16 Class II Asbestos Work

Activities involving the removal of ACM which is not thermal system insulation or surfacing material. This includes, but it not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics.

1.3.17 Class III Asbestos Work

Repair and maintenance operations, where "ACM", including thermal system insulation and surfacing material, is likely to be disturbed.

1.3.18 Clean Room

An uncontaminated room having facilities for storage of employees' street clothing and uncontaminated materials and equipment.

1.3.19 Competent Person

In addition to the definition in 29 CFR 1926.32(f), one who is capable of identifying existing asbestos hazards in the workplace and selecting the appropriate control strategy for asbestos exposure, who has the authority to take prompt corrective measures to eliminate them, as specified in 29 CFR 1926.32 (f); in addition, for Class I and Class II work, one who is specially trained in a training course which meet the criteria of EPA's Model Accreditation Plan (40 CFR 763) for project designer or supervisor, or its equivalent and, for Class II who is trained in an operations and maintenance (O&M) course developed by EPA (40 CFR 763.92 (a)(2)).

1.3.20 Critical Barrier

One or more layers of plastic sealed over all openings into a work area or any other similarly placed physical barrier sufficient to prevent airborne asbestos in work area from migrating to an adjacent area.

1.3.21 Decontamination Area

An enclosed area adjacent and connected to the regulated area and consisting of an equipment room, shower area, and clean room which is used for the decontamination of workers, materials and equipment contaminated with asbestos.

1.3.22 Demolition

The wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos products.

1.3.23 Disturbances

Contact which releases fibers from ACM or PACM or debris containing ACM or PACM. This term includes activities that disrupt the matrix of ACM or PACM, render ACM or PACM friable, or generate visible debris. Disturbance includes cutting away small amounts of ACM and PACM, no greater than the amount which can be contained in one standard sized glove bag or waste bag in order to access a building component. In no event shall the amount of ACM or PACM so disturbed exceed that which can be contained in one glove bag or waste bag which shall not exceed 60 inches in length and width.

1.3.24 Employee Exposure

That exposure to airborne asbestos that would occur if the employee were not using respiratory protective equipment.

1.3.25 Encapsulant

A liquid material which can be applied to ACM which controls the possible release of asbestos fibers from the material either by creating a membrane over the surface (bridging encapsulant) or by penetrating into the material and binding its components together (penetrating encapsulant).

1.3.26 Encapsulate

The process whereby an encapsulant is applied to ACM to control the release of asbestos fibers into the air.

1.3.27 Equipment Room (Change Room)

A contaminated room located within the decontamination area that is supplied with impermeable bags or containers for the disposal of contaminated protective clothing and equipment.

1.3.28 Fiber

A particulate form of asbestos, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1.

1.3.29 Friable Asbestos Material

Material that contains more than 1 percent asbestos by weight which can be crumbled, pulverized, or reduced to powder by hand pressure when dry.

1.3.30 Glovebag Technique

A method with limited applications for removing small sections of asbestos-containing material from HVAC ducts, short piping runs, valves, joints, elbows, and other nonplanar surfaces in a noncontained regulated area. The glovebag is constructed and installed in such a manner that it surrounds the object or material to be removed and contains all asbestos fibers released during the removal process. All workers who are permitted to use the glovebag technique must be highly trained, experienced and skilled in this method.

1.3.31 Glovebag

An impervious plastic bag-like enclosure affixed around an asbestos-containing material, with glove-like appendages through which material and tools may be handled. Shall be made of 6 mil thick plastic and shall be seamless at the bottom.

1.3.32 HEPA Filter Equipment

High-efficiency particulate air (HEPA) filtered vacuuming equipment with a UL 586 filter system capable of collecting and retaining at least 99.97 percent of all mono-dispersed particles of 0.3 micrometer diameter particles or larger.

1.3.33 Homogeneous Area

An area of surfacing material or thermal system insulation that is uniform in color and texture.

1.3.34 Intact

ACM which has not been crumbled, pulverized, or otherwise deteriorated so that it is no longer likely to be bound with its matrix.

1.3.35 Negative Initial Exposure Assessment

A demonstration which complies with the criteria in this section, that employee exposure during an operation is expected to be consistently below the PEL's.

1.3.36 Nonfriable Asbestos Material

Material that contains asbestos in which the fibers have been locked in by a bonding agent, coating, binder, or other material so that the asbestos is well bound and may not release fibers in excess of the action level during any appropriate use, handling, storage, transportation, or processing. Nonfriable asbestos material is considered hazardous during removal and disposal procedures.

1.3.37 (PACM) Presumed Asbestos Containing Material

Thermal system insulation and surfacing material found in buildings constructed no later than 1980.

1.3.38 Personal Monitoring

Sampling of airborne asbestos fiber concentrations within the breathing zone of an employee.

1.3.39 Prior Experience

Experience required of the Contractor, his employees, and his Industrial Hygienist on asbestos projects of similar nature and scope to insure capability of performing the asbestos removal in a satisfactory manner. Similarities shall be in areas related to material composition, project size, number of employees and the engineering work practice and personal protection controls required.

1.3.40 Regulated Areas

An area established to demarcate areas where Class I, II and III asbestos work is conducted, and any adjoining area where debris and waste from such asbestos work accumulate; and a work area within which airborne concentrations of asbestos, exceed or there is a reasonable possibility they may exceed the permissible exposure limit.

1.3.40.1 Enclosed Regulated Area

A regulated area which has been isolated by physical boundaries to prevent the spread of asbestos dust, fibers, or debris. A local exhaust system is required.

1.3.41 Regulated Asbestos-Containing Material (RACM)

(a) Friable asbestos material

(b) Category I nonfriable ACM that has become friable

(c) Category I nonfriable ACM that will become or has been subjected to sanding, grinding, cutting, or abrading; and

(d) Category II nonfriable ACM that has a high probability of becoming crumbled, pulverized, or reduced to powder by the forces acting on the material in the course of the demolition or renovation operation.

1.3.42 Thermal System Insulation (TSI)

ACM applied to pipes, fittings, boilers, breeching, tanks, ducts or other structural components to prevent heat loss or gain.

1.3.43 Thermal System Insulation ACM

Thermal system insulation which contains more than 1% asbestos.

1.3.44 Time Weighted Average (TWA)

The TWA is an 8-hour time weighted average of airborne concentration of fibers per cubic centimeter of air.

1.4 SUBMITTALS

The following shall be submitted in accordance with Section "SUBMITTALS" and approved by the Resident Engineer prior to commencing any work involving asbestos materials:

A: Data

Local Exhaust Equipment

HEPA Vacuum Equipment

Respirators

B: Statements

Testing Laboratory

Submit the name, address, and telephone number of the testing laboratory selected to perform the monitoring, testing, and reporting of airborne concentrations of asbestos fibers along with certification that persons counting the samples have been judged proficient by successful participation within the last year in the National Institute for Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program.

Industrial Hygienist

Submit the name, address, and telephone number of the Industrial Hygienist selected to prepare the asbestos plan, direct monitoring and perform training, and a certification that the Industrial Hygienist is certified by the American Board of Industrial Hygiene, including certification number and date and is experienced in asbestos removal activities.

Prior Experience
(1) As evidence that the asbestos removal effort will be accomplished by trained and competent personnel totally familiar with safe and legal asbestos working practices, the Contractor shall furnish for Government approval (for himself or for his selected asbestos removal subcontractor) written demonstration of successfully completed asbestos abatement projects of similar nature and scope. A short summary of three (3) asbestos abatement projects performed shall include:

a. The name, address, and telephone number of the contact person (someone specifically familiar with the Contractor's work). If available, include copies of letters of reference from previous users of service.

b. A short description of the type of removal (e.g. pipe lagging, sprayed girders and/or ceilings, transite siding, etc.), its extent (square feet, linear feet), and days to complete (scheduled and actual),

c. Documentation of any licenses or certifications as an asbestos abatement Contractor in the jurisdiction covered. If none, a negative response is required.

d. The Contractor shall certify that the firm and its employees are familiar with regulations of the Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) cited in the project specification and related to asbestos abatement.

e. The Contractor shall further document that at least one on-site representative, such as a foreman or management-level person or other authorized representative, trained in the provisions of this regulation and the means of complying with them, is present. Every 2 years, the trained on-site individual shall receive refresher training in the provisions of this regulation. The required training shall include as a minimum: applicability; notifications; material identification; control procedures for removals including, at least, wetting, local exhaust ventilation, negative pressure enclosures, glove-bag procedures, and High Efficiency Particulate Air (HEPA) filters; waste disposal work practices; reporting and recordkeeping; and asbestos hazards and worker protection. Evidence that the required training has been completed shall be posted and made available for inspection by the NESHAPS-administering agency at the demolition or renovation site.

f. A notarized statement, signed by an officer of the asbestos abatement company, containing the following information: (If none, a negative reply is required.)

(2) A record of any citations issued by Federal, State or local regulatory agencies relating to asbestos abatement activity. Include projects, dates and resolutions.

(3) A list of penalties incurred through noncompliance with asbestos abatement project specifications including liquidated damages, overruns in scheduled time limitations and resolutions.

(4) Situations in which an asbestos related contract has been terminated including projects, dates and reasons for terminations.

(5) A listing of any asbestos-related legal proceedings/claims in which the Contractor (or employees scheduled to participated in this project) have participated or are currently involved. Include descriptions of role, issue and resolution to date.

Asbestos Plan

Submit a detailed Plan of the work procedures to be used in the removal and disposal of materials containing asbestos and include an explanation of the Initial Exposure Assessment. The Plan shall be prepared, signed, and sealed, including certification number and date, by the Contractor's Industrial Hygienist. Such Plan shall include a sketch showing the location, size, and details of regulated areas, location and details of the decontamination area, layout of decontamination area, and locations of local exhaust equipment. The Plan shall also include interface of trades involved in the construction, sequencing of asbestos-related work, abatement work, safety, and disposal plan, signage details, type of wetting agent to be used, air monitoring, respirators, protective equipment, pressure differential monitoring device, a disconnection schedule of utility services (where applicable), and a detailed description of the method employed in order to control pollution. The Plan shall be approved by the Resident Engineer prior to the start of any asbestos work. Prior to beginning work, the Contractor shall meet with the Resident Engineer to discuss in detail the Asbestos Plan, including work procedures and safety precautions.

Material Safety Data Sheets (MSDS)

Hazard Communication Plan

Notification Requirements

a. Initial Notification

The Contractor shall:

(1) Provide the U.S. Environmental Protection Agency (EPA) Regional NESHAPS-administering agency with the notice of intention to demolish or renovate at least 10 business days prior to intended start date of the abatement. Copies of this form and any renotification forms shall be furnished to the Resident Engineer. Work shall not commence on any dates other than those stated in the notification without renotification of all parties. Delivery of the notice by U.S. Postal Service, commercial delivery service, or hand delivery is acceptable.

(2) Update notice, as necessary, including when the amount of asbestos affected changes by at least 20 percent.

(3) Postmark or deliver the notice as follows:

At least 10 working days before asbestos stripping or removal work or any other activity begins such as site preparation that would break up, dislodge or similarly disturb asbestos material.

b. Renotification

For asbestos stripping or removal work in a demolition or renovation operation that will begin on a date other than the one contained in the original notice, notice of the new start date must be provided to the NESHAPS-administering agency as follows:

(1) When the asbestos stripping or removal operation or demolition operation covered by this paragraph will begin after the date contained in the notice,

(a) Notify the NESHAPS-administering agency of the new start date by telephone as soon as possible before the original start date, and

(b) Provide the NESHAPS-administering agency with a written notice of the new start date as soon as possible before, and no later than, the original start date. Delivery of the updated notice by the U.S. Postal Service commercial delivery service, or hand delivery is acceptable.

(2) When the asbestos stripping or removal operation or demolition operation covered by this paragraph will begin on a date earlier than the original start date, provide the NESHPAS-administering agency with a written notice of the new start date at least 10 working days before asbestos stripping or removal work begins.

(3) In no event shall an operation covered by this paragraph begin on a date other than the date contained in the written notice of the new start date.

c. Notification Information

The following shall be included in the notice:

(1) An indication of whether the notice is the original or a revised notification.

(2) Name, address, and telephone number of both the facility owner and operator and the asbestos removal contractor.

(3) Type of operation: demolition or renovation.

(4) Description of the facility or affected part of the facility including the size (square feet and number of floors), age, and present and prior use of the facility.

(5) Procedure, including analytical methods, employed to detect the presence of RACM and Category I and Category II nonfriable ACM.

(6) Estimate of the approximate amount of RACM to be removed from the facility in terms of length of pipe in linear feet, surface area in square feet on other facility components, or volume in cubic feet if off the facility components. Also, estimate the approximate amount of Category I and Category II nonfriable ACM in the affected part of the facility that will not be removed before demolition.

(7) Location and street address (including building number or name and floor or room number, if appropriate), city, county, and state, of the facility being demolished or renovated.

(8) Description of procedures to be followed in the event that unexpected RACM is found or Category II nonfriable ACM becomes crumbled, pulverized, or reduced to powder.

C: Reports

Monitoring Results

Fiber counting shall be completed and results reviewed by the Industrial Hygienist within 16 hours of air sample collection. The Industrial Hygienist shall notify the Contractor and the Resident Engineer immediately of any exposures to fibers in excess of the acceptable limits. Submit monitoring results to the Resident Engineer within 3 working days, signed by the testing laboratory employee performing air monitoring, the employee that tested the sample, and the Industrial Hygienist.

Job Progress Report

During abatement activities, the Industrial Hygienist shall submit a weekly job progress report to the Resident Engineer detailing abatement activities. Include review of progress with respect to Asbestos Plan, milestones and schedules, major problems and actions taken, injury reports, equipment breakdown and a compilation of the week's bulk material and air sampling results conducted by the Contractor's Industrial Hygienist or air sampling professional. Submission of individual monitoring results will be as dictated by SD-09, Reports. The progress report shall be signed by the Contractor, asbestos abatement subcontractor and the Industrial Hygienist.

D: Records

Landfill Delivery Records

Submit written evidence that the landfill for disposal is approved for asbestos disposal by the state and local regulatory agencies. Submit copies of all waste shipment records and resulting correspondence.

1.5 TITLE TO MATERIALS

Materials resulting from demolition work, except as specified otherwise, shall become the responsibility of the Contractor and shall be disposed of as specified herein.

1.6 PROTECTION OF EXISTING WORK TO REMAIN

Perform demolition work without damage or contamination of adjacent work. Where such work is damaged or contaminated, restore work to the original condition.

1.7 SEQUENCE OF WORK

No other work shall be performed in the asbestos regulated area prior to completion and certification of the asbestos abatement work.

1.8 PERMISSIBLE EXPOSURE LIMITS (PELS)

a. Time-weighted average limit (TWA). Ensure that no employee is exposed to an airborne concentration of asbestos in excess of 0.1 fiber per cubic centimeter of air as an eight (8) hour time-weighted average (TWA).

b. Excursion limit. Ensure that no employee is exposed to an airborne concentration of asbestos in excess of 1.0 fiber per cubic centimeter of air (1 f/cc) as averaged over a sampling period of thirty (30) minutes.

1.9 MEDICAL SURVEILLANCE 29 CFR 1926.1101(m)

1.9.1 Medical examinations

Institute a medical surveillance program for all employees who for a combined total of 30 or more days per year are engaged in Class I, II and III work or are exposed at or above the permissible exposure limit or excursion limit, and for employees who wear negative pressure respirators. The content of the examination shall be consistent with 29 CFR 1926.1101 (m). This examination is not required if adequate records show the employee has been examined as required by 29 CFR 1926.1101 (m) within the past year. The same medical examination shall be given on an annual basis to employees engaged in an occupation involving asbestos fibers and within 30 calendars days before or after the termination of employment in such occupation.

1.9.2 Medical Records

Maintain complete and accurate records as required by 29 CFR 1926.1101(n) employees' medical examinations for a period of at least 30 years after termination of employment and make records of the required medical examinations available for inspection and copying to: The Assistant Secretary of Labor for Occupational Safety and Health, The Director of the National Institute for Occupational Safety and Health (NIOSH), authorized representatives of either, and an employee's physician upon the request of the employee or former employee.

1.10 TRAINING

Each employee must have received an equivalent level of training within 3 months prior to assignment to asbestos work or shall be instructed for a minimum of 8 hours by the Industrial Hygienist with regard to the methods of recognizing asbestos; the health effects associated with asbestos; the relationship between smoking and asbestos in producing lung cancer; its purposes, proper use, fitting instructions, and limitations of respirators; the nature of operations that could result in exposure to asbestos, the importance of necessary protective controls to minimize exposure and any necessary instructions in the use of these controls and procedures; the appropriate work practices for performing the asbestos removal job; medical surveillance program requirements; and a review of 29 CFR 1926.59 safety and health precautions and the use and requirements for protective clothing and equipment including respirators. Fully cover engineering and other hazard control techniques and procedures. Maintain complete and accurate records of training for each employee. Records shall be maintained for one year beyond the last date of employment.

1.11 Accreditation of Asbestos Removal Personnel

a. In order to qualify for initial accreditation as an asbestos project supervisor, a person shall meet the following requirements:

(1) Have a minimum of six (6) months experience as an asbestos project supervisor or as an asbestos worker.

(2) Have attend an approved training course for asbestos project supervision and received a passing score on the written examination for such course during the twelve (12) months prior to submitting an application.

b. In order to qualify for initial accreditation as an asbestos worker, a person shall have attended an approved training course for asbestos workers or an approved training course for asbestos project supervisors and received a passing score on the written examination for such course during the twelve(12) months prior to submitting an application.

1.12 PERMITS

Obtain necessary permits in conjunction with this project for the transportation and disposition of asbestos containing materials, and provide timely notification of such actions as may be required by Federal, State, regional, and local authorities.

1.13 SAFETY AND HEALTH COMPLIANCE

In addition to detailed requirements of this specifications, comply with laws, ordinances, rules, and regulations of Federal, State, regional, and local authorities regarding handling, storing, transporting, and disposing of asbestos waste materials. Comply with the applicable requirements of the current issue of 29 CFR 1910.1001, 29 CFR 1926.1101, and 40 CFR 61, Subpart A and 40 CFR 61, Subpart M. Submit matters of interpretation of standards to the appropriate administrative agency for resolution before starting work. Where specification requirements and referenced documents vary, the most stringent requirement shall apply.

PART 2 PRODUCTS

2.1 EQUIPMENT AND MATERIAL USED IN REMOVAL OPERATIONS

Furnish the Resident Engineer with two complete sets of personal protective equipment, as required herein, for each entry into and inspection of the regulated area.

2.2 RESPIRATORS

Select respirators approved by the Mine Safety and Health Administration (MSHA) and the National Institute for Occupational Safety and Health (NIOSH), Department of Health and Human Services, for use in atmospheres containing asbestos fibers. Provide personnel engaged in the removal or demolition of pipes, structures, or equipment covered or insulated with asbestos, or in the removal or demolition of asbestos insulation or covering, with Type C supplied air respirators or half face elastomeric respirators with P-100 Cartriges. During the performance of work when removal or demolition of asbestos materials is not underway and after the TWA and ceiling limit has been established, the Contractor shall provide respirators as required in 29 CFR 1926.1101(h)

RESPIRATOR PROTECTION FOR ASBESTOS FIBERS

Airborne concentration of asbestos or condition of use	Required respirator
Not in excess of 1 f/cc (10XPEL), or otherwise as required independent of exposure	Half-mask air purifying respirator other than a disposable respirator, equipped with high efficiency filters.
Not in excess of 5 f/cc (50XPEL).	Full facepiece air-purifying respirator equipped with high efficiency filters.
Not in excess of 10 f/cc (100XPEL).	Any powered air-purifying respirator equipped with high efficiency filters or any supplied air respirator operated in continuous flow.
Not in excess of 100 f/cc (1,000XPEL), or unknown. concentration	Full facepiece supplied air respirator operated in pressure demand mode, equipped with an aux-

iliary positive pressure self-contained breathing apparatus.

*A high efficiency filter means a filter that is at least 99.97 percent efficient against mono-dispersed particles of 0.3 micrometers in diameter or larger.

*Air purifying respirators must be equipped with high-efficiency particulate air (HEPA) filters. The HEPA filters are not reusable.

(3) Respirator program. Establish a respirator program as required by ANSI Z88.2-80 and 29 CFR 1910.134.

2.3 SPECIAL CLOTHING

2.3.1 Protective Clothing

Protective clothing shall be coveralls or similar whole-body clothing, headcoverings, gloves, and foot coverings.

2.3.2 Work Clothing

Provide cloth work clothes to wear under the protective coveralls and foot covering.

2.4 HYGIENE FACILITIES

A decontamination area shall consist of an equipment room, shower area, and clean room in series. The equipment room shall be supplied with impermeable, labeled bags and containers for the containment and disposal of contaminated protective equipment. Shower facilities shall be provided which comply with 29 CFR 1910.14(d)(3). The clean change room shall be equipped with a locker or appropriate storage container for each employee's use.

2.5 EYE PROTECTION

Provide goggles for personnel engaged in asbestos operations when the use of a full face respirator is not required.

2.6 WARNING SIGNS AND LABELS

2.6.1 Warning Signs

Warning signs must be of sufficient size to be clearly legible and display the following information:

DANGER

ASBESTOS

CANCER AND LUNG DISEASE HAZARD

AUTHORIZED PERSONNEL ONLY

RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA

2.6.2 Warning Labels

Labels must be of sufficient size to be clearly legible, printed in large, bold letters on a contrasting background, and displaying the following legend:

DANGER

CONTAINS ASBESTOS FIBERS

AVOID CREATING DUST

CANCER AND LUNG DISEASE HAZARD

2.7 LOCAL EXHAUST SYSTEM

Provide a local exhaust system in the enclosed regulated areas. Filters on vacuums and exhaust equipment shall be UL 586-labeled HEPA filters. Local exhaust equipment shall be sufficient to maintain a minimum pressure differential of minus 0.02 inches of water column relative to adjacent, unsealed areas. The local exhaust system must be equipped with a manometer-type negative pressure differential monitor with minor scale division of 0.02 inch of water and accuracy within plus or minus 1.0 percent. The manometer must be calibrated daily as recommended by the manufacturer. Provide manually recorded manometer readings of the pressure differential between the enclosed regulated area and adjacent unsealed areas at the beginning of each workday and every 2 working hours
thereafter. The local exhaust system shall be operated continuously, 24 hours per day, until the regulated area enclosure is removed. Replace filters as required to maintain the efficiency of the system. The building heating, ventilating, and air-conditioning (HVAC) system shall not be used as the local exhaust system for the enclosed regulated area.

2.8 TOOLS AND MISCELLANEOUS EQUIPMENT

2.8.1 Airless Sprayer

An airless sprayer, suitable for application of sealing material, shall be used.

2.8.2 Scaffolding

Scaffolding, as required to accomplish the specified work, shall meet all applicable safety regulations.

2.8.3 Transportation Equipment

Transportation equipment, as required, shall be suitable for loading, temporary storage, transporting, And unloading of contaminated waste without exposure to persons or property.

2.8.4 Vacuum Equipment

All vacuum equipment utilized in the work area shall utilize HEPA filtration systems.

2.8.5 Water Sprayer

The water sprayer shall be an airless or other low pressure sprayer for amended water application.

2.8.6 Other Tools and Equipment

The Contractor shall provide other suitable tools for the stripping, removal, encapsulation and disposal activities including but not limited to: knives, stiff nylon brushes, sponges, rounded edge shovels, brooms, and carts.

2.9 MATERIALS

2.9.1 Lockdown Sealant

The sealing agent shall be penetrating sealants and shall meet the following criteria:

a. They shall withstand most impact or abrasion and protect the surface.

b. Sealants selected for use by the Contractor shall be one of those demonstrating probable effective Performance under the tests conducted by an independent testing laboratory and are approved by the Contracting Officer’s Representative.

c. They shall have high flame retardant characteristics, and a low toxic fume and smoke emission rating.

d. They shall not be noxious or toxic to application workers, or subsequent workers in the area.

e. They shall have some permeability to water vapor to prevent condensation accumulation, and resist solution by common cleaning agents. They shall be water insolvable when cured.

f. They shall be acceptable weathering and aging characteristics.

g. They shall be acceptable by architectural standards.

h. They shall be compatible with all insulating material likely to be applied to the stripped surfaces.

i. They shall be demonstrably capable of adhering to the surfaces of the substrate.

j. They must contain a light blue or red paint tint. (Food coloring is not acceptable.)

PART 3 EXECUTION

3.1 GENERAL

3.1.1 Respirator Program.

Establish a respirator program as required by ANSI Z88.2 and 20 CFR 1910.134.

3.1.2 Protective Clothing

Provide and require the use of protective clothing for any employee entering or performing work inside of the asbestos control area.

3.1.3 Hygiene Facilities

For employees performing Class I work involving over 25 linear or 10 square feet of TSI or surfacing ACM and PACM, establish a decontamination area that consists of an equipment room, shower area, and clean room in series. Ensure that employees enter and exit the regulated area through the Decontamination area. Where it is demonstrated that it is not feasible to locate the shower between the equipment room and the clean room, or where work is performed outdoors, ensure that employees remove asbestos contamination from their worksuits in the equipment room using a HEPA vacuum before proceeding to a shower.

For employees performing Class I work involving less than 25 linear or 10 square feet of TSI or surfacing ACM and PACM, and for Class II and Class III work where exposures exceed a PEL, establish a equipment room or area that is adjacent to the regulated area which is covered by a impermeable drop cloth on the floor or horizontal working surface. The area must be of sufficient size as to accommodate cleaning of equipment and removing personal protective equipment. Ensure that employees enter and exit the regulated area through the equipment room or area.

3.1.4 Warning Signs and Labels

Provide warning signs at approaches to regulated areas containing airborne asbestos fibers. Locate signs at such a distance that personnel may read the sign and take the necessary protective steps required before entering the area. Provide labels and affix to asbestos materials, scrap, waste, debris, and other products contaminated with asbestos.

3.1.5 Accessibility of Work Areas

The Government will rearrange areas to the extent of providing a reasonable, direct, and unobstructed path to the work sites. During asbestos removal, the Contractor shall confine his equipment and employee pattern to these designated areas. Where the building is still occupied during the removal operations, interference with the functional operation of the building occupants outside these areas will not be permitted. Where conflicts arise due to Contractor's operations, the decision of the Resident Engineer or his authorized representative shall be final.

3.1.6 Preparation for Removal

3.1.6.1 Movable Furnishings

Some movable furnishings, equipment and fixtures in the work area will be pre-cleaned and removed from the area of work by the Government before asbestos work begins. Contractor to remove any remaining items prior to start of asbestos work.

3.1.6.2 Pre-Cleaning

All wall and floor surface areas, other than those from which surface areas, other than those from which asbestos is to be removed, and all non-movable asbestos is to be removed, and all non-movable furnishings, equipment, and fixtures remaining in the work area shall be pre-cleaned with a HEPA filter equipped vacuuming device or wet cleaning methods prior to sealing with plastic sheeting. Do not use any methods which would raise dust such as dry sweeping or vacuuming with equipment not equipped with HEPA filters. After pre-cleaning, enclose fixed objects in 6-mil polyethylene sheeting, label, and seal securely with tape. Objects which must remain in the work area and that require special ventilation or enclosure requirements shall be suitably protected as approved by the Resident Engineer. Items in the work area which may require access by User during abatement shall be designated during the pre-abatement walkthrough and enclosures constructed with access flops sealed with waterproof tape.

3.1.7 Regulated Areas

All Class I, II, and III asbestos work shall be conducted within regulated areas. The regulated area shall be demarcated in any manner that minimizes the number of persons within the area and protects persons outside the area from exposure to airborne concentrations of asbestos. Where critical Barriers or negative pressure enclosures are used, demarcate the regulated area. Signs shall be provided and displayed pursuant to 29 CFR 1026.1101(k)(6). Access to regulated areas shall be limited to authorized persons. All persons entering a regulated area where employees are required to wear respirators, shall be supplied with a respirator. All personnel wearing a respirator shall be medically cleared and fit tested. All asbestos work performed within regulated areas shall be supervised by a competent person.

3.1.7.1 Non-Enclosed Regulated Area Requirements

The construction of an enclosed regulated area is impractical for removal activities. Provide a 20-foot roped off perimeter around the area where asbestos handling procedures are performed and maintain other requirements for regulated areas. Also, where an enclosure
is not provided, conduct personal and area monitoring of airborne fibers during the work shift at the designated limits downwind of the asbestos work area at not less than once every 4 hours. If the concentration of airborne asbestos fibers monitored at the designated limits at any time exceeds the lesser of two times the background or the action level, evacuate personnel in adjacent areas. If adjacent areas are contaminated, clean the contaminated areas, monitor, and visually inspect the area as specified herein.

3.2 ASBESTOS ABATEMENT PROCEDURES

3.2.1 Initial Exposure Assessment

Ensure that a "competent person" conducts an exposure assessment immediately before or at the initiation of the operation to ascertain expected exposures during that operation or workplace. The assessment must be completed in time to comply with requirements which are triggered by Exposure data or the lack of a "negative exposure assessment," and to provide information necessary to assure that all control systems planned are appropriate for that operation and will work properly.

An Initial Exposure Assessment shall be conducted in accordance with 29 CFR 1926.1101

For Class I asbestos work, until exposure monitoring is conducted, and is documented that employees on the job will not be exposed in excess of the PELs, or otherwise makes a negative exposure assessment, it is presumed that employees are exposed in excess of the TWA and excursion limit. A negative exposure assessment can only be obtained by demonstrating requirements contained in 29 CFR 1926.1101.

3.2.2 Monitoring Requirements

Perform exposure monitoring as required to determine accurately the airborne concentrations of asbestos to which employees are exposed. Determinations of employee exposure shall be made from breathing zone air samples that are representative of the 8-hour TWA and 30-minute short-term Exposures of each employee. Representative 8-hour TWA employee exposure shall be determined on the basis of one or more samples representing full-shift exposure for employees in each work area. Representative 30-minute short-term employee exposures shall be determined on the basis of one or more samples representing 30 minute exposures associated with operations that are most likely to produce exposures above the excursion limit for employees in each work area.

3.2.2.1 Background Monitoring Prior to Asbestos Work

Provide area monitoring and establish the reference TWA l day prior to the masking and sealing operations for each asbestos removal site. The reference TWA is determined by taking at least three general area air samples in each asbestos regulated area.

3.2.2.2 Periodic monitoring

Conduct daily monitoring that is representative of the exposure of each employee who is assigned to work within a regulated area who is performing Class I or II work unless a negative exposure assessment for the entire operation has been made. Conduct periodic monitoring of all work where Exposures are expected to exceed a PEL at intervals sufficient to document the validity of the exposure prediction. When all employees required to be monitored daily are equipped with supplied-air respirators operated in the positive-pressure mode, daily monitoring is not required. However, Employees performing Class I work using a control method which is not listed in Class I Requirements paragraph, shall continue to be monitored daily even if they are equipped with supplied-air respirators.

3.2.2.3 Monitoring Adjacent Areas Prior to Asbestos Work

Provide area monitoring and establish the reference TWA inside the building outside the enclosed regulated area l day prior to beginning asbestos work.

3.2.2.4 Termination of Monitoring

If the periodic monitoring reveals that employee exposures, as indicated by statistically reliable measurement, are below the PEL and excursion limit, monitoring may be discontinued for those employee whose exposures are represented by such monitoring. Institute additional monitoring whenever there has been a change in process, control equipment, personnel or work practices that may result in new or additional exposures above the PEL and/or excursion limit.

3.2.3 Respiratory Protection

Respirators shall be used during all Class I work, during all Class II work where the ACM is not removed in a substantially intact state, during all Class II and III work which is not performed using wet methods, during all Class II and III work where a negative exposure assessment is not produced, and during all Class III jobs where TSI or surfacing ACM or PACM is being disturbed. Provide the appropriate respirator as specified.

3.2.4 Controls and Work Practices

The following controls and work practices shall be used in all classes of work regardless of levels of exposure:

a. Vacuum cleaners equipped with HEPA filters to collect all debris and dust containing ACM or PACM

b. Wet methods, or wetting agents, to control employee exposures during asbestos shandling, Mixing, removal, cutting, application, and cleanup, except where demonstrated that the use of Wet methods are infeasible

c. Prompt clean-up and disposal of wastes and debris contaminated with asbestos in leak-tight Container

d. Local exhaust ventilation equipped with HEPA filter dust collection systems

e. Enclosure or isolation of processes producing asbestos dust

f. Ventilation of the regulated area to move contaminated air away from the breathing zone and Toward a filtration or collection device equipped with a HEPA filter

The following work practices and controls shall not be used for work related to asbestos or the work which disturbs ACM or PACM, regardless of measured levels of asbestos exposure or results of the initial exposure assessments:

a. High-speed abrasive disc saws that are not equipped with point of cut ventilator or enclosures with HEPA filters exhaust air;

b. Compressed air used to remove asbestos, or ACM, unless the compressed air is used in conjunction with an enclosed ventilation system designed to capture the dust cloud created by the compressed air;

c. Dry sweeping, shoveling or other dry clean-up and debris containing ACM and PACM;

d. Employee rotation as a means of reducing employee exposure to asbestos.

3.2.5 Class I Abatement Requirements

In addition to all provisions required in control and work methods above, the following controls and work practices shall be used for all Class I work.

a. Installation and operation of the control systems, shall be supervised by a competent person.

b. Work involving the removal of more than 25 linear or 10 square feet of thermal system insulation or surfacing material; for all other Class I jobs, where a negative exposure assessment, or where employees are working in areas adjacent to the regulated area, while the Class I work is being performed, use one of the following methods to ensure that airborne asbestos does not migrate from the regulated areas:

(1) Critical barriers shall be placed over all openings to the regulated area;

(2) Use another barrier or isolation method which prevents the migration of airborne asbestos from the regulated area, as verified by perimeter area surveillance during each work shift at each boundary of the regulated area, showing no visible asbestos dust; and perimeter area monitoring showing that clearance levels contained in 40 CFR Part 763, Subpt. 3, or that perimeter area levels are no more than background levels representing the same area before the asbestos work began.

c. HVAC systems shall be isolated in the regulated area by sealing with a double layer of 6 mil plastic or the equivalent;

d. Impermeable dropcloths shall be placed on surfaces beneath all removal activity;

e. All objects within the regulated area shall be covered with impermeable dropcloths or plastic sheeting which is secured by duct tape or an equivalent.

f. Where a negative exposure assessment cannot be produced, or where exposure monitoring shows that a PEL is exceeded, ventilate the regulated area to move contaminated air away from the breathing zone of employees toward a HEPA filtration or collection device.

3.2.5.1 Negative Pressure Enclosure (NPE) Systems

A Negative Pressure Enclosure (NPE) System shall be used where the configuration of the work area does not make the erection of the enclosure infeasible. Specifications and work practices shall be as required in 29 CFR 1926.1101(g)(5).

3.2.5.2 Glovebag Systems

Glovebag systems shall be used to remove PACM and/or ACM from straight runs of piping with the following specifications and work practices. Each glovebag shall be installed so that it completely covers the circumference of pipe or other structure where the work is to be done. Shall be smoke-tested for leaks and any leaks sealed prior to use and may be used only once and may not be moved. Shall not be used on surfaces whose temperature exceeds 150 degrees. Prior to disposal, they shall be collapsed by removing air within them using a HEPA vacuum. Before beginning the operation, loose and friable material adjacent to the glovebag/box operation shall be wrapped and sealed in two layers of six mil plastic or otherwise rendered intact.

Where system uses attached waste bag, such bag shall be connected to collection bag using hose or other material which shall withstand pressure of ACM waste and water without losing its integrity. Sliding valve or other device shall separate waste bag from hose to ensure no exposure when waste bag is disconnected.

At least two persons shall be required to perform Class I glovebag removals.

3.2.5.3 Negative Pressure Glove Bag Systems

A Negative Pressure Glove Bag System shall be used to remove ACM or PACM from piping. Attach HEPA vacuum systems or other devices to bag to prevent collapse during removal and run continually during the operation. Where a separate waste bag is used along with a collection bag and discarded after one use, the collection bag may be reused if rinsed clean with amended water before reuse.

3.2.5.4 Negative Pressure Glove Box Systems

A Negative Pressure Glove Box System shall be used to remove ACM or PACM from pipe runs. Box shall be constructed with rigid sides and made from metal or other material which can withstand the weight of the ACM and PACM and water used during removal. A negative pressure generator shall be used to create negative pressure in system. An air filtration unit shall be attached to the box. The box shall be fitted with gloved apertures. An aperture at the base of the box shall serve as a bagging outlet for waste ACM and water. A back-up generator shall be present on site. The box shall be smoke tested prior to each use. At least two persons shall perform the removal.

3.2.5.5 Water Spray Process System

A Water spray Process System shall be used for removal of ACM and PACM from cold line piping if, employees carrying out such process have completed a 40-hour separate training course in its use, in addition to training required for employees performing Class I work. Piping shall be surrounded on 3 sides by rigid framing. A 360 degree water spray, delivered through nozzles supplied by a high pressure separate water line, shall be formed around the piping. The system shall be operated by at least three persons, one of whom shall not perform removal, but shall check equipment, and ensure proper operation of the system. After removal, the ACM and PACM shall be bagged while still inside the water barrier.

3.2.5.6 Intact Asbestos Insulated Pipe Removal

When both piping and insulation are to be removed tintact, wet he insulation, then, using glovebag technique, remove 10-inch to 12-inch section of the pipe insulation and encapsulate exposed edges of the asbestos insulation to remain, remove the glovebag, cut and remove the intact insulated pipe. Long components removed intact may be wrapped in 2 layers or 6-mil polyethylene sheeting secured with tape at the ends, prior to or after cutting the pipe, for transport to the landfill. Intact insulated pipe shall be removed in manageable sections.

3.2.6 Class II Abatement Requirements

Class II asbestos work shall be performed by complying with work practices and controls designated for each type of asbestos work to be performed set out in 29 CFR1926.1101((g)(7). Class II work also may be performed using a method allowed for Class I work, except that glove bags and glove boxes are allowed if they fully enclose the Class II material to be removed.

3.2.6.1 Vinyl and Asphalt Flooring Materials

a. The material (floor tile and black mastic) shall be thoroughly wetted with amended water prior to and during its removal.

b. The materical shall be removed in an intact state unless the employer demonstrates that intact removal is not possible. When tiles are heated and can be removed intact, wetting may be omitted.

c. Cutting, abrading, or breaking the material shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release are not feasible.

d. ACM removed shall be immediately bagged or wrapped, or kept wetted until transferred to a closed receptacle, no later than the end of the work shift.

e. Flooring or its backing shall not be sanded.

f. Vacuums equipped with HEPA filter, disposable dust bag, and metal floor tool (no brush) shall be used to clean floors.

g. All scraping of residual adhesive and/or backing shall be performed using wet methods.

h. Dry sweeping is prohibited.

i. Mechanical chipping is prohibited unless performed in a negative pressure enclosure which meets the requirement of this section.

3.2.6.2 Roofing Material Removal

a. Roofing material shall be removed in an intact state to the extent feasible.

b. Wet methods shall be used where feasible.

c. Cutting machines shall be continuously misted during use, unless a competent person determines that misting substantially decreases worker safety.

d. All loose dust left by the sawing operation must be HEPA vacuumed immediately.

e. Unwrapped or unbagged roofing material shall be immediately lowered to the ground via covered dust-tight chute, crane or hoist, or placed in an impermeable waste bag or wrapped in plastic sheeting and lowered to ground no later than the end of the work shift.

f. Upon being lowered, unwrapped material shall be transferred to a closed receptacle in such manner so as to preclude the dispersion of dust.

g. Roof level heating and ventilation air intake sources shall be isolated or the ventilation system shall be shut off.

3.2.6.3 Cementitious Asbestos-Containing Siding and Shingles or Transite Panels

a. Cutting, abrading or breaking siding, shingles, or transite panels, shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release cannot be used.

b. Each panel or shingle shall be sprayed with amended water prior to removal.

c. Unwrapped or unbagged panels or shingles shall be immediately lowered to the ground via covered dust-tight chute, crane or hoist, or placed in an impervious waste bag or wrapped in plastic sheeting and lowered to the ground no later than the end of the work shift.

d. Nails shall be cut with flat, sharp instruments.

3.2.6.4 Gaskets Containing ACM

a. If visibly deteriorated and unlikely to be removed intact, removal shall be undertaken within a glovebag.

b. The gasket shall be thoroughly wetted with amended water prior to its removal.

c. The wet gasket shall be immediately placed in a disposal container.

d. Any scraping to remove residue must be performed wet.

3.2.6.5 Transite Board Removal Method

The wallboard material shall be sprayed with a lockdown sealant in order to reduce the potential of fiber release and the fasteners and board shall be removed. After removal, the wallboard shall be wrapped in two layers of 6-mil plastic and sealed with tape. If the size of the wallboard permits, the wrapped material shall be placed in drums for disposal. The wallboard shall not be sawed, crushed or abraded at any time during removal. Clean up shall consist of HEPA vacuuming any accumulated asbestos debris and spraying of lockdown sealant on the framing to which the wallboard material was fastened.

3.2.6.6 Trowelled-On Wall Plaster Removal Method

The material is sprayed with amended water and saturated sufficiently to wet it to the substrate without causing excess dripping. Remove the saturated material in small sections. The asbestos material is sprayed repeatedly during the work process to maintain wet conditions and to minimize asbestos fiber dispersion. As it is removed, the material is placed in 6-mil plastic bags and appropriate containers for disposal.

3.2.6.7 Black Mastic on Roof Drain Piping Removal

a. The material shall be thoroughly wetted with amended water prior and during its removal.

b. Two layers of ground cover shall be applied under the piping during abatement.

c. The pipe shall be removed in an intact state unless the employer demonstrates that intact removal is not possible.
d. Vacuums equipped HEPA filter shall be used to clean the area surrounding the pipe.

e. Cutting, abrading, or breaking the material shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release are not feasible.

f. ACM removed shall be immediately bagged or wrapped, or kept wetted until transfer to a closed receptacle, no later than the end of the work shift.

3.2.6.8 Fire Door and Chalkboard Removal

1. The material shall be thoroughly wetted with amended water prior and during its removal.

2. The materials shall be removed in an intact state.

3. ACM removed shall be immediately bagged or wrapped, or kept wetted until transferred to a closed receptacle, no later than the end of the work shift.

3.2.6.9 Any other Class II Removal of ACM

a. The material shall be thoroughly wetted with amended water prior and during its removal.

b. The material shall be removed in an intact state unless the employer demonstrates that intact removal is not possible.

c. Cutting, abrading, or breaking the material shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release are not feasible.

d. ACM removed shall be immediately bagged or wrapped, or kept wetted until. transferred to a closed receptacle, no later than the end of the work shift.

3.2.7 Class III Asbestos Work

Class III work shall be performed using wet methods. To the extent feasible, work shall be performed using local exhaust ventilation. Where disturbance involves drilling, cutting, etc., use impermeable dropcloths, and shall isolate the operation using mini-enclosures or glovebag systems. Work which involves the disturbance of TSI require respirators.

3.3 COLLECTION

3.3.1 Nonfriable Non-Regulated Asbestos Containing Material (Non-RACM)

The following types of non-friable ACM that may be found in this project are considered non-RACM and do not require special collection action:

Vinyl Asbestos Flooring
Asphalt Roofing

All notification requirements are still applicable, however, to Non-RACM.

3.3.2 Regulated Asbestos Containing Material (RACM)

Asbestos containing material shall be removed in manageable sections. Removed material should be containerized before moving to a new location for continuance of work. Surrounding areas within the 20-foot perimeter shall be periodically sprayed and maintained in a wet condition until visible material is cleaned up.

Maintain surfaces of the regulated area free of accumulations of asbestos fibers. Restrict the spread of dust and debris; keep waste from being distributed over the general area. Do not dry sweep or blow down the space with compressed air. Clean all surfaces in the work area and other contaminated areas with water. When asbestos removal, disposal, and cleanup are complete, the Contractor shall certify, in writing, that the concentration of airborne fibers in the regulated area is less than 0.0l fibers (longer than 5 micrometers) per cubic centimeters of air. Do not remove the regulated area enclosure or roped-off perimeter and caution signs prior to the Resident Engineer's receipt of the certification. After final cleanup, remove filters on the building HVAC system and provide new filters. Dispose of filters as asbestos-contaminated waste. Reestablish HVAC, mechanical, and electrical systems in proper working order. The Resident Engineer will visually inspect the affected surfaces for residual asbestos material and accumulated dust; the Contractor shall reclean areas showing dust or residual asbestos materials. If recleaning is required, monitor the airborne fiber concentration after recleaning. Notify the Resident Engineer before unrestricted entry is permitted. The Government shall have the option to perform independent monitoring to certify the areas are safe before entry is permitted.

Collect asbestos waste, scrap, debris, bags, containers, equipment, and asbestos-contaminated clothing which may produce airborne concentrations of asbestos fibers; place in sealed impermeable bags imprinted with a caution label and shall also be labeled with the name of the Contractor and the location at which the waste was generated. Place bags in disposable asbestos-waste drums. Steel drums are not allowed.

Label wrapped materials that will not fit in drums in the same manner as described in para. 1. above.

3.3.2.1 Removing Material Intact

Asbestos containing material removed from the building shall not be dropped or thrown to the ground. Material should be removed as intact sections whenever possible and carefully lowered to the ground. Materials between 15 and 50 feet above the ground may be containerized at elevated levels or placed into inclined chutes or scaffolding for subsequent collection and containerization. Asbestos materials in open containers shall be kept wet at all times.

3.3.2.2 Containers

Containers (drums or 6-mil polyethylene bags) shall be sealed when full. Wet material will be heavy and double bagging of waste material is usually necessary. A determination of need for single or double bags must be made early in the abatement process and approved by the Resident Engineer.

Bags, if used, shall not be overfilled. They should be securely sealed to prevent accidental opening and leakage by tying tops of bags in an overhand knot or by taping in gooseneck fashion. Do not seal bags with wire or cord. Bags may be placed in drums for staging and transportation to the landfill. Bags shall be decontaminated on exterior surfaces by wet cleaning before being placed in clean drums and sealed with locking ring tops. Where unusual circumstances prohibit use of plastic disposal bags or drums, the Contractor shall submit, in the asbestos plan, an alternate proposal for removal, containerizing, and disposal of the asbestos materials and fibers.

3.3.2.3 Sharp-Edged Components

Asbestos containing or contaminated waste with sharp edged components (e.g. nails, screws, metal lath, tin sheeting) that could otherwise tear polyethylene bags shall be placed into drums for disposal.

3.3.2.4 Asbestos Contaminated Soil

The removed soil shall be placed in 6-mil plastic bags, sealed and then placed in asbestos waste drums for disposal. Do not overfill plastic bags.

3.3.2.5 Wastewater

a. Pre-filtering. Any water produced by the decontamination of either equipment or persons shall be (1) collected, (2) filtered through a system capable of trapping particles 5 microns and larger, specifically designed to remove asbestos fibers, and (3) drummed for off site disposal or filtrate disposed into a local sanitary sewer system.

b. Filter System. The filtration system shall contain a series of several filters with progressively smaller pore sizes to avoid rapid clogging of the system by large particles. Disposable filters shall be treated as asbestos waste.

3.4 DISPOSAL OF ACM

3.4.1 Nonfriable Non-Regulated Asbestos Containing Material (Non-RACM)

The following types of non-friable ACM that may be found in this project are considered non-RACM and do not require special disposal action:

Vinyl Asbestos Flooring
Asphalt Roofing

All notification requirements are still applicable, however, to Non-RACM.

3.4.2 Regulated Asbestos Containing Material (RACM)

The contractor to whom this section applies shall comply with the following procedures:

1. Mix asbestos-containing waste from control devices with water to form a slurry; adequately wet other asbestos-containing waste material; and

2. After wetting, seal all asbestos-containing waste material in leak-tight containers while wet; and IV. Label the containers as follows: CAUTION! CONTAINS ASBESTOS - AVOID OPENING OR BREAKING CONTAINER. BREATHING ASBESTOS IS HAZARDOUS TO YOUR HEALTH.

3. Discharge no visible emissions to the outside air during the collection, processing, packaging, transporting or deposition of any asbestos-containing waste material.

4. Once drums, bags and otherwise containerized asbestos containing materials have been removed from the work area, they shall be loaded into an enclosed truck for transportation to the designated landfill. Asbestos waste shall not be allowed to be placed in trucks with non-asbestos waste.

5. The enclosed cargo area of the truck shall be free of debris and lined with 6-mil polyethylene sheeting to prevent contamination from leaking or spilled containers. Floor sheeting shall be installed first and extend up the sidewalls. Wall sheeting shall be overlapped and taped into place so that no materials may escape to the environment.

6. Drums shall be placed on level surfaces in the cargo area and packed tightly together to prevent shifting and tipping. Do not throw containers into the cargo area.

7. Personnel loading asbestos containing waste shall be protected by disposable clothing including head, body and foot protection and at a minimum, half-face piece, air purifying, dual cartridge respirators equipped with high efficiently particulate air (HEPA) filters.

8. Large steel dumpsters (roll-off type) may be used for asbestos waste disposal. These should be lined with polyethylene and should have doors, tops or covers that can be closed to prevent vandalism or other disturbance of the containerized asbestos debris and wind dispersion of asbestos fibers. Uncontainerized asbestos materials shall not be placed in these type dumpsters, nor shall they be used for non-asbestos waste. Bags shall be placed, not thrown, into these containers to avoid splitting.

9. Dispose of waste asbestos material at a State DEP permitted sanitary landfill off Government property.

10. For temporary storage, store sealed impermeable bags in asbestos waste drums. An area for interim storage of asbestos waste-containing drums will be assigned by the Resident Engineer or by an authorized representative. This area must be secure. No ACM wastes, except those properly labeled and properly containerized and physically located in the assigned holding area shall be allowed to remain at the site overnight.

11. Procedure for hauling and disposal shall comply with 40 CFR 6l, Subpart M, 40 CFR 241, 40 CFR 257, and State, regional and local standards. Vehicles used to transport asbestos-containing waste material must be marked as follows:

Mark vehicles used to transport asbestos-containing waste material during the loading and unloading of the waste so that the signs are visible. The markings must:

(i) Be displayed in such a manner and location that a person can easily read the legend.

(ii) Conform to the requirements for 51 cm x 36 cm (20 in. x 14 in.) upright format signs specified in 29 CFR 1910.145(d)(4) and this paragraph; and

(iii) Display the following legend in the lower panel with letter sizes and styles of a visibility at least equal to those specified in this paragraph.

Legend

DANGER
ASBESTOS DUST HAZARD
CANCER AND LUNG DISEASE HAZARD
Authorized Personnel Only

Notation
2.5 cm (1 inch) Sans Serif, Gothic or Block
2.5 cm (1 inch) Sans Serif, Gothic or Block

1.9 cm (3/4 inch) Sans Serif, Gothic or Block 14 Point Gothic

Spacing between any two lines must be at least equal to the height of the upper of the two lines.

12. Upon reaching the landfill, trucks are to approach the dump location as closely as possible for unloading of the asbestos containing waste.

13. Bags, drums and components shall be inspected as they are offloaded at the disposal site. Material in damaged containers shall be repacked in empty drums or bags as necessary.

14. Waste containers shall be placed on the ground at the disposal site, not pushed or thrown out of trucks since the weight of wet material could rupture containers.

15. Personnel off-loading containers at the disposal site shall wear protective equipment consisting of disposable head, body and foot protection and, at a minimum, half-face piece, air-purifying, dual cartridge respirators equipped with high efficiency particulate air (HEPA) filters. Following the removal of all containerized waste, the truck cargo area shall be decontaminated to meet the no visible residue criteria. Polyethylene sheeting shall be removed and discarded along with contaminated cleaning materials and protective clothing, in bags or drums at the disposal site. If landfill personnel have not been provided with personal protective equipment for the compaction operation by the landfill operator, Contractor shall supply protective clothing and respiratory protection for the duration of this operation.

16. Shipment Records

a. Maintain waste shipment records, using a form similar to that shown at the end of this section and include the following information:

(i) The name, address, and telephone number of the waste generator.

(ii) The name and address of the local, State, or EPA Regionaloffice responsible for administering the asbestos NESHAP program.

(iii) The approximate quantity in cubic meters (cubic years).

(iv) The name and telephone number of the disposal site operator.

(v) The name and physical site location of the disposal site.

(vi) The date transported.

(vii) The name, address, and telephone number of the transporter(s).

(viii) A certification that the contents of this consignment are fully and accurately described by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and government regulations.

b. Provide a copy of the waste shipment record, described above to the disposal site owners or operators at the same time as the asbestos-containing waste material is delivered to the disposal site.

c. For waste shipments where a copy of the waste shipment record, signed by the owner or operator of the designated disposal site, is not received by the Contractor within 35 days of the date the waste was transported, contact the owner or operator of the designated disposal site to determine the status of the waste shipment. The Contractor shall report in writing to the NESHAP-administering agency if a copy of the waste shipment record, signed by the owner or operator of the designated waste disposal site, is not received by the Contractor within 45 days of the date the waste was transported. Include in the report the following information:

(i) A copy of the waste shipment record for which a confirmation of delivery was not received, and
(ii) A cover letter explaining the efforts taken to locate the asbestos waste shipment and the results of those efforts.

d. Retain a copy of all waste shipment records, including a copy of the waste shipment record signed by the owner or operator of the designated waste disposal site, for at least 2 years.

e. Provide to the Resident Engineer within 3 working days following delivery of asbestos containing waste material (ACWM), copies of all waste shipment records. Also within 3 working days of initiation, provide to the Resident Engineer copies of any correspondence with the NESHAP-administering agency.

Furnish upon request, and make available for inspection by the NESHAP-administering agency, all records under this section.

3.4.3 Wastewater

It is the Contractor's responsibility to comply with any local wastewater systems' regulations or policy regarding the disposal of wastewater from asbestos abatement activities.

3.5 CLEANUP AND FINAL CLEARANCE

3.5.1 Visual Inspection After Cleanup

Prior to the performance of final air monitoring, the Contractor and the Resident Engineer or his representative shall perform a visual inspection for asbestos dust/residue. If residue is found, additional wipedown/vacuuming shall be performed to satisfaction of the Resident Engineer.

3.5.2 Monitoring After Final Cleanup

After the removal site has passed the visual inspection, provide area monitoring of fibers (at least 3 samples per removal site) under aggressive conditions and establish the TWA of less than 0.0l fibers (longer than 5 micrometers) per cubic centimeter of air after final cleanup but before removal of the enclosure of the regulated area. Provide area monitoring and establish the TWA 2 days and 5 days after the enclosure of the regulated area is removed. Provide area monitoring and establish the TWA after final cleanup when an enclosure is not required. The fiber counts from the samples shall be less than 0.0l fibers (longer than 5 micrometers) per cubic centimeter of air or be not greater than the reference TWA, whichever is less. Should any of the final samplings indicate a higher value, the Contractor shall take appropriate actions to reclean the area and shall repeat the monitoring.

3.5.3 Air Sampling

Air Sampling under aggressive conditions shall include the following procedures:

a. Before starting the sampling pumps, direct the exhaust from forced air equipment (such as l horsepower leaf blower) against all walls, ceiling, floors, ledges and other surfaces in the room. This should take at least 5 minutes per 1000 sq. ft. of floor.

b. Place a 20-inch fan in the center of the room. (Use one fan per 10,000 cubic feet of room space.) Place the fan on slow speed and point it toward the ceiling.

c. Start the sampling pumps and sample for the required time.

d. Turn off the pump and then the fan(s) when sampling is complete.

3.5.4 Air Clearance Failure

Should clearance sampling results fail to meet the final cleanup requirements, the Contractor shall take appropriate action at no additional cost to the Government, to reclean, resample, and analyze data until final cleanup requirements are met.

3.5.5 Site Inspection

While performing asbestos removal work, the Contractor shall be subject to onsite inspection by the Resident Engineer who may be assisted by safety or health personnel. If the work is in violation of specification requirements, the Resident Engineer will issue a stop work order to be in effect immediately and until the violation is resolved. Standby time and expenses required to resolve the violation shall be at the Contractor's expense.

3.5.6 Sealing Permanent Exposed Surfaces (RACM)

After the asbestos material has been removed and HEPA vacuumed to the greatest extent possible, all permanent asbestos exposed interior surfaces shall be coated with an approved lockdown sealant to permanently bind any remaining fibers in place. Sealant shall be applied by airless sprayers and in accordance with the sealant manufacturers recommendations.

3.5.7 Sealant Tint

The sealant shall have an adequate tint to easily distinguish between sections sealed and sections not sealed.

3.5.8 Reestablishment of the Work Area

Reestablishment of the work area shall only occur following the completion of clean-up procedures and after clearance air monitoring has been performed and documented to the satisfaction of the Resident Engineer.

3.5.9 Visual Inspection

The Contractor and Resident Engineer shall visually inspect the work area for any remaining visible residue. Evidence of asbestos materials will necessitate additional cleaning requirements.

3.5.10 Clearance of Work Area

Following satisfactory clearance of the work area, remaining barriers may be removed and disposed of as asbestos contaminated waste.

3.5.11 Remaining Building Demolition Procedures

Contractor may proceed with remaining building demolition procedures after complying with the removal and disposal of paint with lead abatement specification, removal and disposal of totally enclosed PCBs abatement specification, and all other federal, state, and local requirements.

END OF SECTION 02 82 33

CERTIFICATE OF WORKER'S RELEASE

DATE: ____________________

TO: ____
(Insert Owner's Name and Address)

RE: ____
(Insert Project Name and Address)

In consideration of my employment by _________________________________ in
(Contractor)
connection with the removal and disposal of asbestos, or other work in asbestos-contaminated work areas, and in consideration of the sum of ONE AND NO/100 ($1.00) DOLLAR and other good and valuable consideration in hand paid, at and before the sealing and delivery of these presents, the receipt, sufficiency, and adequacy of which are hereby acknowledged, the undersigned does hereby acknowledge, warrant, represent, covenant, and agree as follows:

1. I acknowledge and understand that I have been or will be employed in connection with the removal of, disposal of, or other treatment to, asbestos, or other work in asbestos-contaminated work areas, and I
acknowledge that in handling asbestos and breathing asbestos dust, including, but not limited to, THE FACT THAT ASBESTOS CAN CAUSE ASBESTOSIS AND IS A KNOWN CARCINOGEN, AND CAN THEREFORE CAUSE VARIOUS TYPES OF CANCER.

2. I acknowledge and understand that ANY CONTACT WITH ASBESTOS, WHETHER IT CAN BE SEEN OR NOT, MAY CAUSE ASBESTOSIS AND VARIOUS FORMS OF CANCER, WHICH MAY NOT SHOW UP FOR MANY YEARS, AND I covenant and agree faithfully to take all precautions required of me.

3. I knowingly assume all risks in connection with potential exposure to asbestos and I do hereby release and forever discharge Owner, Architect, independent laboratory or engineers employed by the Owner or Architect, and all of their directors, officers, employees, nominees, personal representatives, affiliates, successors, and assigns from and against any and all liability whatsoever, at common law or otherwise, except any rights which the undersigned may have under the provisions of the applicable Workmen's Compensation Laws. Expect as specifically set forth herein, I hereby waive and relinquish any and all claims of every nature which I now have or may have or claim to have which are in any way, directly or indirectly related to exposure of asbestos and asbestos-containing materials.

______________________________	______________________________
Name of Worker (Must be typed)	Signature of Worker (As acknowledgement of reading this page of this two-page Certificate.)

CERTIFICATE OF WORKER'S RELEASE, Cont.

4. I hereby warrant and represent that I have not been disabled, laid-off, or compensated in damages or otherwise, because of the disease of asbestosis.

SIGNATURE____

SOCIAL SECURITY NUMBER____

SIGNED IN PRESENCE OF:

____
Notary No. and Seal

(Submit one copy for each employee prior to employee staring work.)

SPECIAL ENDORSEMENT (INSURANCE)

Attached to and forming a part of Policy No. ______________________________________of the
_____________________ issued at is ____ Agency.
(Name of Insurance Company) (City) (State)

Date of endorsement____for

____
(Name of Project)

In consideration of the premium for which the policy is written and proper rate adjustment when applicable, the insurance company agrees as follows:

> The insurance company agrees that this policy shall not be cancelled, changed, allowed to lapse, or expire until 30 days after the Owner has received written notice thereof as evidenced by return receipt of registered letter or until such time as other valid and effective insurance coverage acceptable in every respect to the Owner and providing protection equal to protection called for in the policy shown below shall have been received, accepted, and acknowledged by the Owner.
>
> The insurance company acknowledges and agrees that this policy is applicable for Contractor or Subcontractor whose business is asbestos removal or asbestos abatement.
>
> Any other provisions to the contrary notwithstanding, coverage under this policy shall specifically include all operations of asbestos abatement required by the project named above.

The forgoing insurance provisions have been incorporated into the reference and are hereby made a part of Insurance Policy No. _______________, this ____________ day of ___________________________, 20__.

____
(Name of Company)

____
(Signature of Authorized Representative)

EMPLOYEE SAFETY INSTRUCTION FORM

Employee Name: ____

Employee Address: ____

Employee Telephone No.: ____

Union Card Number: ____

Classification of Worker: ____

Have you had in the past, or present, any respiratory problems?

Yes__________No _________

Have you worked in the past with asbestos or fiberglass type materials?

Yes _________No _________

The project you will be working on involves the use of asbestos and the removal of the asbestos from the building. Asbestos is considered a health hazard.

The company is supplying all necessary safety clothing and working conditions required and necessary for your protection from asbestos hazard.

You shall be instructed at commencement of the job on the required use of safety equipment, clothing, working conditions and procedures. These must be rigidly adhered to. Smoking is not permitted in the work areas. Disregarding of safety instructions shall result in instant dismissal.

I acknowledge that safety instructions have been given to my by the company at my work commencement and I am thoroughly conversant with them and have answered the above questions truthfully.

Signed ____
Employee

Date ______________________________

(Submit one copy for each employee prior to employee starting work.)

RESPIRATOR TRAINING CERTIFICATION

PROJECT NAME: ____

I hereby certify that I have been trained in the use of each type of respiratory protection equipment required for use on this Project. The training included the following:

1. Explanation of dangers related to misuse.

2. Instruction on putting on, fitting, testing and wearing the respirator.

3. Instruction on inspection, cleaning and maintaining the respirator.

4. Instruction on emergency situations.

I further certify that I understand the use, care and inspection of the respirator and have tested and work the unit.

Signed: ______________________________

Date: ______________________________

Superintendent's Signature: __________________________

(Submit one copy for each employee prior to employee starting work)

CERTIFICATE OF VISITOR'S RELEASE

DATE: ___________________________

TO: ____
(Insert Project Name and Address)

In consideration of my visit(s) to the above named project in connection with the removal and disposal of asbestos, or other work in asbestos-contaminated work areas, the undersigned does hereby acknowledge, warrant, represent, covenant, and agree as follows:

1. I acknowledge and understand that I have been or will be employed in connection with the removal of, disposal of, or other treatment to, asbestos, or other work in asbestos contaminated work areas, and I acknowledge that I have been advised of and I understand the dangers inherent in handling asbestos and breathing asbestos dust, including, but not limited to, THE FACT THAT ASBESTOS CAN CAUSE ASBESTOSIS AND IS A KNOWN CARCINOGEN AND CAN, THEREFORE, CAUSE VARIOUS TYPES OF CANCER.

2. I acknowledge and understand that ANY CONTACT WITH ASBESTOS, WHETHER IT CAN BE SEEN OR NOT, MAY CAUSE ASBESTOSIS AND VARIOUS FORMS OR CANCER, WHICH MAY NOT SHOW UP FOR MANY YEARS, and I covenant and agree faithfully to take all precautions required of me.

____
Signature of Visitor
(as acknowledgement of reading this page 1 of this two-page Certificate)

3. I knowingly assume all risks in connection with potential exposure to asbestos and I do hereby, for myself and my heirs at law, release and forever discharge Owner, Owner's Representative, Architect, independent testing laboratory or engineers employed by the Owner, Owner's Representative, Architect, and all of their directors, officers, employees, nominees, personal representatives, affiliates, successor, and assigns from and against any and all liability whatsoever, at common law or otherwise, except any rights the applicable workmen's compensation laws. Except as specifically set forth herein I hereby waive and relinquish any and all claims of every nature which I now have or may have or claim to have which are in any way, directly or indirectly, related to exposure to asbestos and asbestos-containing materials.

4. I hereby warrant and represent that I have not been disabled, laid-off, or compensated in damages or otherwise, because of the disease of asbestosis.

Signature____

Social Security Number_____________________________

Signed in presence of:

____
(General Superintendent)

SECTION 03 01 00 - REHABILITATION OF CONCRETE

PART 1 GENERAL

1.1 SCOPE

This specification governs the rehabilitation of structural concrete.

1.2 DEFINITIONS

1.2.1 BRACING

Temporary supplemental members used to avoid local or global instability during construction, evaluation, or repair that are intended to be removed after completion of construction.

1.2.2 DELAMINATION

A planar separation in a material that is roughly parallel to the surface of the material.

1.2.3 REHABILITATION

Repairing or modifying an existing structure to a desired useful condition.

1.2.4 REPAIR

The reconstruction or renewal of concrete parts of an existing structure for its maintenance or to correct deterioration, damage, or faulty construction of members or systems of a structure.

1.2.5 SHORING

Props or posts of timber or other material in compression used for the temporary support of excavations, formwork, or unsafe structures; the process of erecting shores.

1.2.6 TERMINATION

The interface where a placement of repair material meets existing concrete, the edge of an expansion joint, or other existing surfaces.

1.2.7 UNSOUND CONCRETE

Concrete that is fractured, delaminated, spalled, deteriorated, defective, contaminated, or otherwise damaged.

1.3 REFERENCES

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 288 (2017) Standard Specification for Geosynthetic Specification for Highway Applications

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 117 (2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary

ACI 440.5	(2008) Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars
ACI 440.6	(2008) Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement
ACI 440.8	(2013) Specification for Carbon and Glass Fiber-Reinforced Polymer (FRP) Materials Made by Wet Layup for External Strengthening of Concrete and Masonry Structures
ACI 503.2-503.4	(2010, R 2003) Three Epoxy Specifications
ACI 503.3	(2010) Specification for Producing a Skid-Resistant Surface on Concrete by the Use of Epoxy and Aggregate
ACI 503.7	(2007) Specification for Crack Repair by Epoxy Injection
ACI 548.10	(2010) Specification for Type MMS (Methyl Methacrylate Slurry) Polymer Overlays for Bridge and Parking Garage Decks
ACI 548.12	(2012) Specification for Bonding Hardened Concrete and Steel to Hardened Concrete with an Epoxy Adhesive
ACI 548.4	(2011) Standard Specification for Latex-Modified Concrete (LMC) Overlays
ACI 548.8	(2007) Specification for Type EM (Epoxy Multi-Layer) Polymer Overlay for Bridge and Parking Garage Decks
ACI 548.9	(2008) Specification for Type ES (Epoxy Slurry) Polymer Overlay for Bridge and Parking Garage Decks

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE/SEI 37	(2015) Design Loads on Structures During Construction

ASTM INTERNATIONAL (ASTM)

ASTM A775/A775M	(2017) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A780/A780M	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A934/A934M	(2016) Standard Specification for

	Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM C1059/C1059M	(2013) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1438	(2013; R 2017) Standard Specification for Latex and Powder Polymer Modifiers for use in Hydraulic Cement Concrete and Mortar
ASTM C1583/C1583M	(2013) Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)
ASTM C1600/C1600M	(2017) Standard Specification for Rapid Hardening Hydraulic Cement
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C33/C33M	(2016) Standard Specification for Concrete Aggregates
ASTM C387/C387M	(2015) Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
ASTM C42/C42M	(2013) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C496/C496M	(2017) Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C881/C881M	(2015) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C882/C882M	(2013a) Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C928/C928M	(2013) Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs
ASTM D1078	(2011) Standard Test Method for Distillation Range of Volatile Organic Liquids
ASTM D2103	(2015) Standard Specification for Polyethylene Film and Sheeting
ASTM D226/D226M	(2017) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

ASTM D2822/D2822M	(2005; R 2011; E 2011) Standard Specification for Asphalt Roof Cement, Asbestos-Containing
ASTM D323	(2015a) Vapor Pressure of Petroleum Products (Reid Method)
ASTM D3418	(2015) Transition Temperatures of Polymers by Differential Scanning Calorimetry
ASTM D4016	(2014) Viscosity of Chemical Grouts by Brook field Viscometer (Laboratory Method)
ASTM D450/D450M	(2007; E 2013; R 2013) Coal-Tar Pitch Used In Roofing, Damp proofing, and Waterproofing
ASTM D4580/D4580M	(2012) Standard Practice for Measuring Delamination's in Concrete Bridge Decks by Sounding
ASTM D4869/D4869M	(2016a) Standard Specification for Asphalt-Saturated Organic Felt Underlayment Used in Steep Slope Roofing
ASTM D542	(2014) Index of Refraction of Transparent Organic Plastics
ASTM D93	(2016) Standard Test Methods for Flash-Point by Pensky-Martens Closed Cup Tester
ASTM E329	(2014a) Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 310.2R	(2013) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1.4.1 Preconstruction Submittals

Qualifications; Work Plan; Quality Control Plan;

1.4.2 Product Data

Conventional Concrete; Polymers; Miscellaneous Materials And Equipment

1.4.3 Sample

Reinforcement and Reinforcement Supports; Polymers; Miscellaneous Materials

1.4.4 Design Data

Repair Procedures; Mixture Proportioning

1.4.5 Test Reports

Mixture Proportioning; Quality Control

1.5 QUALITY ASSURANCE

1.5.1 General Requirements

a. Follow the requirements of ACI 318 for Work involving portland cement concrete.

b. To protect personnel from overexposure to toxic materials, conform to the applicable manufacturer's Safety data sheets or local regulations. Submit manufacturer's Safety Data Sheets for all polymers as well as other potentially hazardous materials.

c. Submit the repair procedures for executing the work as well as the test data and documentation on materials used for repair. Submittal must include component materials, mixture proportions, and supplier's quality control program.

d. Inspection and testing of surface preparation as well as placement of reinforcing steel must be in accordance with provisions included herein and the Contract Document.

e. Sampling and testing of materials, as well as inspection and testing of work, must be in accordance with established procedures, manufacturer's instructions, specific instructions from the Contracting Officer if given, or recommended practices as referenced herein and the Contract Documents.

f. Trial batches and testing requirements for various repair materials specified are the responsibility of the Contractor.

g. The testing agency must inspect, sample, and test repair materials and concrete production as required. When it appears that material furnished or work performed by Contractor fails to conform to Contract Documents the testing agency will immediately report such deficiency.

1.5.2 Quality Control Plan

Submit a quality control plan as specified in Sections 01 45 00 CONTRACTOR QUALITY CONTROL.

1.5.3 Qualifications

The submittals must where applicable, identify agencies and individuals who will be working on this contract and their relevant experience. Do not make changes in approved agencies or personnel without prior approval of the Contracting Officer.

1.5.3.1 Testing Agencies

In addition to the requirements of Section 01 45 00.00 10 QUALITY CONTROL, agencies that test concrete materials must meet the requirements of ASTM C1077. Testing agencies that test or inspect placement of reinforcing steel must meet the requirement of ASTM E329. Submit data on qualifications of Contractor's proposed testing agency for acceptance.

1.5.3.2 Quality Control Personnel

Field tests of repair materials required must be made by an ICRI Concrete Surface Repair Technician Tier 2. Submit resumes, pertinent information, past experience, training and education of all operators of specialized demolition equipment if needed for this and the three paragraphs above.

1.5.3.3 Contractor Qualifications

The contractor performing the repair work must have been involved in a minimum of three concrete repair projects similar in size and scope to this project for at least five years. Submit information, including name, dollar value, date, and point-of-contact for similar projects which demonstrates the required experience and/or training.

1.5.3.4 Worker Qualifications

a. Each worker engaged in the use of specialized removal or application equipment, including saw operators and epoxy injection, must have satisfactorily completed an instruction program and three years of experience in the operation of the equipment.

b. Workers installing adhesive anchors must be ACI Adhesive Anchor Installer certified or equivalent.

1.5.3.5 Regulatory Requirements

Perform all work in accordance with applicable Federal, State, and local safety, health, and environmental requirements. The Contractor is responsible for obtaining all permits required by Federal, State, and local agencies for the performance of the work. Responsibilities for the Work to ensure that the Contractor's personnel understand all aspects of the repair material, its properties, and application procedures. The conference must include the Contracting Officer or authorized representative, the Contractor's field superintendent and foreman, and a competent Technical Representative of the material manufacturer, and other involved trades or supplier representatives. The Technical Representative must be fully qualified to perform the work.

1.5.4 Work Plan

Prepare a work plan describing the methods of concrete removal and repair, including methods, equipment, and materials to be used for each feature. Submit the work plan for approval at least 30 days prior to the start of the work. The plan must include, but not be limited to, repair materials to be used with specific information on products and/or constituents, and requirements for handling, storage, etc., equipment to be used, surface preparation, and requirements for placement, finishing, curing, and protection specific to the materials used. Include a description of field demonstrations in the work plan. Do not commence work until the work plan and field demonstration representative of the type of work are approved.

1.6 ACCEPTANCE OF REHABILITATION WORK

1.6.1 General Requirements

a. Completed concrete rehabilitation work must conform to applicable requirements of Contract Document and this specification. The Contractor is responsible to bring Work into compliance with requirements of Contract Documents if the Concrete repair work fails to meet one or more requirements of Contract Documents.

b. Correct rejected repair work by removing and replacing or by strengthening with additional construction acceptable to the Contracting Officer. Use repair methods that meet applicable requirements for function, durability, dimensional tolerances, and appearance.

c. Submit proposed work plan, repair methods, materials, and modifications to the Work needed to correct rejected repair work to meet the requirements of Contract Documents.

1.6.2 Tolerances

a. Construction tolerances for repairs must conform to ACI 117. Where existing conditions do not allow tolerances to conform to ACI 117, use the details and materials for such conditions as indicated in the Contract Documents. For conditions not shown or that are different than indicated in the Contract Documents, notify the Contracting Officer before proceeding with the work at those locations.

b. Inaccurately formed concrete surfaces resulting in concrete members with dimensions that exceed ACI 117 tolerances are subject to rejection.

2.2 EQUIPMENT FOR CONCRETE PREPARATION

Means and methods used for concrete removal and surface preparation must be selected and used such as to minimize damage to the structure and to the concrete substrate that remains.

2.3 MATERIALS FOR FORMWORK AND EMBEDDED ITEMS

a. Formwork and embedded items must meet the requirements specified in ACI 318 and ACI 117.

b. Install and remove formwork without damaging or staining the existing structure or repair material.

c. Forms used for polymer concrete/mortars must be tight enough to hold the material that is used without leaking. All surfaces where bond is not desired, but which are exposed to the monomer or resin, must be treated with a form release agent.

2.4 REINFORCEMENT AND REINFORCEMENT SUPPORTS

2.4.1 Steel Bars, Wires, and Fiber-reinforced Concrete

a. Reinforcement and reinforcement support must be 60 grade steel and meet the requirements specified in ACI 318.

b. Repair coating damage incurred during shipment, storage, handling, and placing of reinforcing bars in accordance with ASTM A780/A780M. Damaged areas must not exceed 2 percent of surface area in each linear foot of each bar.

c. Mechanical splices for coated reinforcement must have compatible coatings, in accordance with manufacturer's instructions. Splices for galvanized reinforcement must be galvanized or coated with dielectric material. Splices used with epoxy-coated or dual-coated reinforcement must be coated with dielectric material.

d. Submit mill certificates and shop drawings as requirement by Section 013000.

2.4.2 Fiber-Reinforced Polymers

a. Fiber-Reinforced Polymers (FRP) bars used as internal reinforcement in concrete and their supports must meet the product requirements of ACI 440.5 and conform to ACI 440.6.

b. Submit test reports and certificates for FRP bars as required by ACI 440.5 and the Contract Documents.

c. Fiber-Reinforced Polymer (FRP) laminate materials externally bonded to concrete made by wet layup must meet the requirements of ACI 440.8 and the Contract Documents. Submit product data sheets for materials used for FRP layup systems as described in ACI 440.8.

d. The use of externally bonded FRP systems other than wet layup systems are permitted upon approval by the Contracting Officer. Submit product and materials data, design data, test reports, certificates, manufacturer's instructions, and field reports for those systems as requested by the Contracting Officer and required by Contract Documents.

2.5 CONVENTIONAL CONCRETE

a. Portland cement concrete materials must achieve a minimum of 4000 psi compressive strength at 28 days and meet the requirements specified in ACI 318.

2.6 POLYMERS

a. The requirements for the properties of polymers and aggregates used in polymers must meet the requirements specified in this paragraph as well as the properties specified in the referenced specifications and the Contract Documents.

b. Polymers used must be compatible with other polymers and materials used on the project. Unless repair materials are specified in the contract documents, the Contractor is responsible for verifying material compatibilities.

c. Submit product data, manufacturer's Safety Data Sheets, samples, design data, test reports, certificates, manufacturer's instructions, and field reports for materials as required by this document as well as the referenced specifications and the Contract Documents.

2.6.1 Epoxies

a. Epoxy mortars used for repairing defects in hardened Portland cement concrete must meet the requirements of ACI 503.2-503.4.

b. Epoxy used for crack repair must meet the requirements of ACI 503.7.

c. Epoxy used to produce a skid-resistant surface on hardened concrete must meet the requirements of ACI 503.3.

d. Epoxy used for overlays must meet the requirements of ACI 548.9.

e. Epoxy used for bonding freshly mixed concrete and hardened concrete must meet the requirements of ASTM C881/C881M, Type II, Grade 2, Class A.

f. Epoxy used for bonding hardened concrete and steel to hardened concrete must meet the requirements of ACI 548.12.

2.6.2 Latexes

a. Latex used in polymer modified Portland cement concrete/mortar must meet the requirements of ASTM C1438.Latex used in polymer modified Portland cement concrete overlays must meet the requirements of ACI 548.4.

b. Latex used for bonding freshly mixed concrete and hardened concrete must meet the requirements of ASTM C1059/C1059M, Type II.

2.7 MISCELLANEOUS MATERIALS AND EQUIPMENT

2.7.1 Packaged and proprietary materials

The required properties for the materials listed in this paragraph must meet the properties specified in the Contract Documents. Submit Product data, samples, test reports, and manufacturer's instructions as required by the Contracting Officer and the Contract Documents.

a. Packaged, rapid hardening concrete repair materials must conform to ASTM C928/C928M.

b. Packaged, mortar and concrete must conform ASTM C387/C387M.

c. Rapid hardening cement must conform to ASTM C1600/C1600M.

d. Water used with packaged and proprietary materials must meet ASTM C1602/C1602M requirements. Aggregates must meet the repair material manufacturer's requirements if available and ASTM C33/C33M if such requirements are not specified.

2.7.2 Bond Breakers

a. Bond breaker materials must meet the requirements of ASTM D2822/D2822M

b. Bond breaker materials used must not have detrimental effects on portland cement concrete and reinforcement.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

3.1.1 Examination

Locate area of unsound concrete or delamination using hammer sounding or chain drag sound methods in accordance to ASTM D4580/D4580M. Denote and mark perimeter boundaries and notify the Contracting Officer to approve the unsound concrete layout boundaries.

3.1.2 Protection

Protect pedestrians, motorized traffic, mechanical, electrical, and plumbing equipment, surrounding construction, project site, landscaping, and surrounding buildings from damage or injury resulting from concrete rehabilitation work.

a. Construct dust and debris barriers surrounding repair work perimeter to control dust and to protect and control construction traffic.

b. Dispose of runoff from wet demolition or surface preparation operations in accordance with all local ordinances. Disposal methods must avoid soil erosion, avoid undermining pavements and foundations, damage to landscaping and vegetation, and minimize water penetration through other parts of buildings.

c. Collect and neutralize alkaline wastes and acid wastes and dispose in accordance with local, state, and federal regulations.

d. Comply with local noise ordinances during demolition operations.

e. Perform demolition work and surface preparation work in a manner that minimizes disturbances of operations. Coordinate work with the Contracting Officer.

f. Submit a proposed protection plan for approval by owner representative and Licensed Design Professional.

3.1.3 Formwork and Shoring

3.1.3.1 Formwork

a. Construct forms to sizes, shapes, lines, and dimensions to match existing adjacent surfaces and textures. Provide forms that match openings, offsets, chamfers, anchorages, inserts and other features as described on Contract Documents. Construct forms to accommodate installation of products by other trades. Provide forms for easy removal to minimize damage to concrete surfaces and adjacent surfaces. Apply form release coating over formwork surfaces prior to each concrete placement. Form release agents must not be applied to or come in contact with the repair area concrete substrate or reinforcement.

b. Do not damage repair material during removal of formwork for columns, walls, sides of beams, and other parts not supporting weight of concrete or repair material. Perform needed repair and treatment required on vertical surfaces at once and follow immediately with specified curing. Remove all formwork anchors embedded in existing concrete. Fill anchor holes and repair all damage to existing concrete at anchor holes.

3.1.3.2 Shoring

a. Provide shoring in accordance with the shoring drawings prior to performing work to brace the substrate structure temporarily while repair work is proceeding. Shoring must be designed, documented, and stamped by a Licensed Design Professional. Shoring designs must be submitted to and approved by the Contracting Officer prior to work commencing.

b. Leave formwork and shoring in place to support existing loads, construction loads and weight of repair material in beams, slabs, and other structural members until in-place strength of repair material determined in accordance with the Contract Documents. For post-tensioned construction, leave formwork and shoring in place until stressing is complete. When shores and other supports are arranged to allow removal of form-facing material without allowing structural slab or member to deflect, form-facing material and its horizontal supporting members may be removed at an earlier age.

3.1.4 Concrete preparation

a. Remove concrete as needed per the removal requirements of this section. Limits on removal equipment are specified in the paragraph titled EQUIPMENT FOR CONCRETE PREPARATION.

b. Remove foreign material, such as dirt, oil, grease, or other chemicals, from the cracks before injection using compressed air, low-pressure water, or vacuuming. Allow wet surfaces to dry at least 24 hours.

c. Immediately before placing the repair material or installing formwork, make the repair area available for inspection by the Contracting Officer. Obtain acceptance by the Contracting Officer of surface preparation before proceeding with Work. If the Work is rejected, perform additional operations to the satisfaction of Contracting Officer.

3.1.5 Quality Control

3.1.5.1 Quality control of surface preparation

Evaluation of prepared substrate must be continuously monitored to assure that the prepared substrate surface meets project requirements.

3.1.5.2 Quality control of repair overlays

All components of overlay PPCC materials must be certified by the material manufacturer or aggregate supplier to meet all project testing requirements. During the PPCC overlay, take mixed samples and check that the materials are mixed properly. Confirm that the right PC overlay thickness was applied by recording the volume of PC overlay materials and the substrate surface area covered by the overlay.

3.1.6 Curing

a. For portland cement concrete Work, follow the requirements indicated in ACI 318.

b. For polymer concrete/mortar Work, follow manufacturer's requirements for curing

c. For polymer modified portland cement concrete Work follow manufacturer's requirements for curing.

3.1.7 Clean up

a. Clean and remove all spills and leaks of injection adhesive and stains caused by the injection adhesives.

b. Dispose wastewater used for cutting and cleaning without staining or damaging the existing surfaces of the structure or the environment of the project area. The method of disposal must meet all the requirements of Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS

3.1.8 Safety

a. Provide Material Safety Data Sheets (MSDS) for products on site reviewing them before work begins.

b. Provide safety guards, maintenance, and warnings for all machinery and equipment.

c. Have personal protection equipment practice in place - eye protection and face guards.

d. Have all workers in contact with wet cementitious material wear protective gloves and clothing.

e. Provide eyewash facilities on-site with location signage.

f. Provide dust masks for workers operating mixers.

g. Have confined space procedures in place including adequate ventilation in closed spaces before operating equipment or using products that emit potentially dangerous or toxic exhaust, fumes, or dust.

h. Provide secured storage available for all hazardous or flammable materials.

i. Conduct safety meetings prior to beginning repair operations.

3.2 CRACK REPAIR

3.2.1 Preparation

3.2.1.1 General Requirements

a. Clean all cracks in accordance with the paragraph titled Concrete Preparation.

b. Do not repair cracks when the temperature of the concrete is below freezing and moisture conditions indicate the possibility of ice on the internal surfaces of the crack.

c. Do not apply adhesive if the temperature of the concrete is not within the range of application temperatures recommended by the manufacturer of the adhesive.

3.2.1.2 Crack routing

Inspect surfaces adjacent to crack to receive repair material. If deteriorated, route a V-groove section at the crack face until sound concrete is reached.

3.2.1.3 Sealing

a. For epoxy injection, apply a surface seal over all exterior faces of the crack that can be reached to contain the injection adhesive in the crack.

b. For gravity fill repairs, apply a surface seal along the bottom surface of the element that can be reached to contain the repair material in the crack.

.3.2.2 Application

3.2.2.1 Epoxy injection

a. Install the injection entry and venting ports using flush mounted or drilled fittings per proprietary manufacturer's instructions.

b. Space the ports at a distance equal to the thickness of the member.

c. Inject the epoxy using material manufacturer's recommended equipment.

d. Apply recommended manufacturer's injection pressure.

e. For vertical or inclined cracks, apply injection by pumping epoxy into entry ports at the lowest elevation, cap, and move upward.

f. For horizontal cracks, apply injection by proceeding from one end of the crack to the other until the crack is fully sealed.

g. After 10 min., repeat injection procedure until all ports refuse injection.

h. Remove ports and remove the surface seal by heat, chipping, or grinding or other acceptable means after the injected epoxy has cured.

3.2.2.2 Gravity fill

a. Mix resin or monomer per material manufacturer's instructions.

b. Pre-fill cracks at least 3 mm 0.125 in. wide with aggregate.

c. Pour resin or monomer onto the surface, over the cracks and spread with brooms, rollers, or squeegees.

d. Work material back and forth over the cracks to maximize fill in crack.

e. Allow at least 20 minutes for material to penetrate cracks.

f. Remove excess material once cracks have been filled to refusal.

g. Broadcast 0.5 to 1.0 kg per square meter 1 to 2 lbs per square yard

h. Allow material to cure per material manufacturer's recommendations.

3.2.3 Quality Control

a. Conduct quality tests for metering accuracy and mixing effectiveness of the continuous mixing pump in accordance with ACI 503.7.

b. Qualify the test injection procedures in accordance with ACI 503.7.

3.2.4 Acceptance Criteria

3.2.4.1 Core Sampling

a. Obtain core samples in accordance with ASTM C42/C42M.

b. Allow 24 hours after injection before coring.

c. Obtain cores in a manner that includes as much of the bond line of the repaired concrete as possible. Replace cores that do not intersect the crack for at least 75 percent of the length of the core.

d. Obtain three diameter core from first 30 m 100 ft. and one core for each 30 m 100 ft. thereafter.

e. If cores would sever reinforcing steel or other embedded items, do not core, and notify the Contracting Officer so that an alternative location can be chosen.

f. Obtain cores at least 50 mm 2 in. in diameter for visual inspections and at least 100 mm 4 in. in diameter for the splitting tensile test. Perform a splitting tensile test on one core from the first 30 m 100 ft. and one core for each 75 m 250 ft. thereafter.

g. Fill core holes with non-shrink grout.

3.2.4.2 Core Testing

a. Test a portion of the core samples for the splitting tensile strength in accordance with ASTM C496/C496M.

b. Allow 72 hours after injection before beginning splitting tensile tests

c. Prepare core sample per ASTM C42/C42M.

d. Align the core so that the crack is in a plane as close to vertical as possible.

3.2.4.3 Acceptance

Work is acceptable if at least 90 percent of the depth of the crack in each core is filled with adhesive.

3.3 CORROSION AND SURFACE REPAIR

3.3.1 Preparation

3.3.1.1 Identification of Extent of Concrete Removal

a. Configure geometry of removal area to maximize the use of right-angle geometry, avoiding reentrant corners, and to obtain uniformity of depth. Determine the depth, location, and size of reinforcing bars prior to removal of concrete.

b. Perform visual inspection and hammer tapping, chain drag sounding, or other methods acceptable by the Contracting Officer to identify cracked, delaminated, spalled, disintegrated, and otherwise unsound concrete for removal. Mark boundaries of repair area before concrete removal.

c. Inspect the marked boundaries with the Contracting Officer prior to commencing with the concrete removal. Revise the repair area boundaries as instructed by the Contracting Officer.

3.3.1.2 Shoring and Formwork

a. Provide shoring and formwork per the paragraph titled Formwork and Shoring.

b. For post-tensioned concrete, detension strands and wires as required by Contract Documents prior to repair.

3.3.1.3 Concrete Removal

a. Remove concrete from repair areas to indicated depth and profile. Notify Contracting Officer if additional delaminated, fractured, or unsound concrete is present.

b. Do not damage embedded reinforcing and adjacent concrete. The removal methods must produce minimal microcracking (bruising) of the prepared substrate surfaces. Avoid directly striking reinforcing steel with impact tools used for concrete removal.

c. Provide perpendicular edges at perimeter of repair area. The perimeter of the repair areas must be saw cut to a depth of 0.50 to 0.75 in. 15 to 20 mm. For vertical or overhead surfaces, provide 45-degree slope at repair boundaries to facilitate air and rebound escape. Do not cut or damage embedded reinforcement or other embedded items. If embedded reinforcing steel or other embedded items are too close to the surface to provide the perpendicular edge cut, notify the Contracting Officer for direction before proceeding.

d. Extend concrete removal along the corroded reinforcing steel to a point where there is no further delamination, concrete cracking, or reinforcing steel corrosion, and where the reinforcement is bonded to the surrounding concrete.

e. Remove concrete around the exposed layer of reinforcement to a uniform depth beyond within the repair areas to provide a minimum clearance between exposed reinforcing steel and surrounding concrete of 0.75 in. 20 mm, or at least 0.25 in. 5 mm larger than the maximum nominal size of the coarse aggregate in the repair material.

3.3.1.4 Preparation of Concrete Substrate Surface

a. Confirm perpendicular edges at repair area perimeter, and reinstate if damaged by concrete removal process. Remove loosely bonded concrete, bruised or fractured concrete, and bond-inhibiting materials such as dirt, concrete slurry, or any other detrimental materials from the concrete substrate using approved methods. Where concrete has been removed by impact methods, abrasive blasting must be used to prepare the surface and remove bruised concrete.

b. Provide substrate surface profiles as specified in the Contract Documents.

c. Visually inspect and sound substrate surface to confirm that no further delaminations or otherwise unsound concrete remains. If encountered, notify the Contracting Officer.

d. Clean the substrate per the paragraph titled Concrete preparation.

3.3.2 Application

3.3.2.1 Existing Reinforcement Preparation

a. Clean existing reinforcement that will remain. Remove corrosion and/or other laitance and notify the Contracting Officer if section loss is greater than 20%.

b. Replace coating on reinforcement per ASTM A780/A780M. Exposed areas must not exceed 2 percent of surface area in each linear foot of each bar.

c. Permit evaluation of existing reinforcement and placement of new reinforcement by the Contracting Officer.

3.3.2.2 Placement of New Reinforcement

Placement of new reinforcement

a. Placement of new reinforcement to replace or strengthen existing reinforcement is like new construction. Placement, splicing, and handling of new reinforcement must meet the requirements specified in ACI 318

b. Reinforcement must be free of materials deleterious to bond. New reinforcement with rust, mill scale, or a combination of both will be considered satisfactory, provided minimum nominal dimensions, nominal weight, and minimum average height of deformations of a hand-wire-brushed test specimen are not less than applicable ASTM specification requirements.

3.3.2.3 Placement of Concrete

a. If portland cement concrete is used as the repair material, follow the requirements indicated in ACI 318 as well the Contract Document for proportioning, mixing, and placing concrete. For all other materials, follow material manufacturer's recommendations.
b. Finish the surface to match surface finish and texture requirements indicated in the Contract Document

3.3.2.4 Placement of Other Repair Materials

a. Equilibrate repair material(s) and substrate to the temperature, cleanliness of substrate and reinforcement, and moisture requirements of the repair material manufacturer's requirements.

b. Comply with the repair material manufacturer's requirements for batching, mixing, placing and curing repair materials.

c. Review consistency of the mixed repair material(s) relative to the parameters documented in the repair material manufacturer product data sheet. If non-conforming, adjust consistency in compliance with the repair material manufacturer's requirements.

d. Apply or install repair material(s) within the application time frame (pot life) requirements of the repair material manufacturer's requirements, and place and consolidate to provide well-compacted repair.

e. Finish and tool repair materials, finished in accordance with the repair material manufacturer's written instructions and as indicated in Contract Documents.

f. Protect installed repair material(s) from damage, exposure to environmental conditions that are detrimental to the uncured or cured properties of the material. Cure in accordance with the requirements of the repair material manufacturer's requirements.

3.3.3 Quality Control

a. Protect concrete surfaces, beyond limits of surfaces receiving bonding agent adhesive, against spillage. Immediately remove any bonding agent adhesive that has spilled beyond desired area. Perform cleanup with material designated by bonding agent adhesive manufacturer. Avoid contamination of work area.

3.5 CONCRETE STRENGTHENING

3.5.1 Preparation

a. Use equipment and methods specified in the paragraph titled EQUIPMENT FOR CONCRETE PREPARATION and the Contract Documents to produce a sound, rough, open-pore surface at locations where bonding between existing and new concrete is required.

b. Round members of existing concrete with corners to minimum 13 mm $^1/_2$ in. radius. Roughened corners must be smoothed with putty

c. Clean all surfaces from contaminant and remove unsound concrete using the prescribed cleaning equipment and methods in the paragraphs titled PRODUCTS. All laitance, dust, dirt, oil, curing compound, existing coatings, and any other matter that could interfere with bonding concrete to the repair material must be removed.

d. Follow the procedures of the paragraphs titled CRACK REPAIR and CORROSION AND SURFACE REPAIR. The concrete surface must be in good condition and all cracking, surface repair, and corrosion related problems must be adequately addressed prior to proceeding with concrete strengthening procedures.

e. Insure that materials used for repairs are compatible with materials used for strengthening. Consult with the repair material manufacturers for information concerning material compatibility.

f. Surfaces not intended to be strengthened must be covered as needed to protect against contamination and spills.

g. Surfaces intended to be strengthened must be protected before application so that no materials that can interfere with bond are redeposited on the surface.

3.5.2 Application

3.5.2.1 Externally bonded systems

3.5.2.2.1 Fiber-reinforced Polymer Laminates

The following procedures are general procedures used for the installation of FRP laminates. If the FRP system used requires conflicting procedures, consult with the Contracting Officer before proceeding.

a. Insure that all surfaces that will receive FRP are clean, dry, and free of contaminants.

b. Insure that the workplace is well ventilated and that the repair material is applied at a time when the air temperature, concrete surface temperature, and the relative humidity are as required by the repair material manufacturer.

c. Temporary protection of the Work area is required during installation and until the resins have cured. If temporary shoring is required, the FRP system must be fully cured before removing the shoring and allowing the structural member to carry the design loads.

d. If a primer is required, the primer must be applied uniformly to all areas on the concrete surface where the FRP system is to be placed at the manufacturer’s specified rate of coverage. Protect the primer from dust, moisture, and other contaminants before applying the FRP system

e. Putty must be used in an appropriate thickness and sequence with the primer as recommended by the FRP manufacturer. The system-compatible putty must be used only to fill voids and smooth surface discontinuities before the application of other materials. Rough edges or trowel lines of cured putty must be ground smooth before continuing the installation. Allow the putty to cure as specified by the FRP system manufacturer before proceeding.

f. Proportion, mix, and apply resins components in accordance with the FRP system manufacturer’s recommended procedures.

g. Install and cure the FRP system per the manufacturer's recommendations.

h. During installation of wet layup FRP systems, entrapped air between layers must be released or rolled out before the resin sets. Sufficient saturating resin must be applied to achieve full saturation of the fibers. Furthermore, successive layers of saturating resin and fiber materials must be placed before the complete cure of the previous layer of resin. If previous layers are cured, interlayer surface preparation, such as light sanding or solvent application as recommended by the system manufacturer, is required.

i. Follow the FRP material manufacturer's recommendations for the application of protective coatings. Do not clean the installed FRP with a solvent before a protective coating is installed.

3.5.3 Quality Control

The cured FRP system must be evaluated for delamination’s or air voids between multiple plies or between the FRP system and the concrete. Methods such as acoustic sounding (hammer sounding), ultrasonics, and thermography can be used to detect delamination’s. The following requirements apply to wet layup systems:

a. Small delamination’s less than 2 square inch 1300 square millimeter each are permissible as long as the delaminated area is less than 5 percent of the total laminate area and there are no more than 10 such delamination’s per 10 square feet square meter.

b. Large delamination’s, greater than 25 square inch 16,000 square millimeter, can affect the performance of the installed FRP and must be repaired by selectively cutting away the affected sheet and applying an overlapping sheet patch of equivalent plies.

c. Delamination’s less than 25 square inch 16,000 square millimeter must be repaired by resin injection or ply replacement.

For other FRP systems, delamination must be evaluated and repaired in accordance with the material manufacturer direction. Upon completion of the Work, the laminate must be reinspected to verify that the repair was properly accomplished.

END SECTION 03 01 00

SECTION 07 21 00 - THERMAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Concealed building insulation.
2. Exposed building insulation.
3. Vapor retarders.
4. Sound attenuation insulation.

1.2 DEFINITIONS

A. Mineral-Fiber Insulation: Insulation composed of rock-wool fibers, slag-wool fibers, or glass fibers; produced in boards and blanket with latter formed into batts (flat-cut lengths) or rolls.

1.3 PERFORMANCE REQUIREMENTS

A. Plenum Rating: Provide glass or slag-wool-fiber/rock-wool-fiber insulation where indicated in ceiling plenums whose test performance is rated as follows for use in plenums as determined by testing identical products per "Erosion Test" and "Mold Growth and Humidity Test" described in UL 181, or on comparable tests from another standard acceptable to authorities having jurisdiction.

1. Erosion Test Results: Insulation shows no visible evidence of cracking, flaking, peeling, or delamination of interior surface of duct assembly, after testing for 4 hours at 2500-fpm air velocity.
2. Mold Growth and Humidity Test Results: Insulation shows no evidence of mold growth, delamination, or other deterioration due to the effects of high humidity, after inoculation with Chaetomium globosium on all surfaces and storing for 60 days at 100 percent relative humidity in the dark.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency for insulation products.

C. Research/Evaluation Reports: For foam-plastic insulation.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of building insulation through one source from a single manufacturer.

B. Fire-Test-Response Characteristics: Provide insulation and related materials with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

1. Surface-Burning Characteristics: ASTM E 84.
2. Fire-Resistance Ratings: ASTM E 119.
3. Combustion Characteristics: ASTM E 136.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect insulation materials from physical damage and from deterioration by moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

B. Protect plastic insulation as follows:

1. Do not expose to sunlight, except to extent necessary for period of installation and concealment.
2. Protect against ignition at all times. Do not deliver plastic insulating materials to Project site before installation time.
3. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 GLASS-FIBER BOARD INSULATION

A. Available Manufacturers:

1. CertainTeed Corporation.
2. Johns Manville.

3. Knauf Fiber Glass.
4. Owens Corning.

B. Unfaced, Flexible Glass-Fiber Board Insulation: ASTM C 612, Type IA; ASTM C 553, Types I, II, and III; or ASTM C 665, Type I; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, passing ASTM E 136 for combustion characteristics; and of the following nominal density and thermal resistivity:

1. Nominal density of 1.0 lb/cu. ft., thermal resistivity of 3.7 deg F x h x sq. ft. /Btu x in. at 75 deg F.

C. Foil-Faced, Flexible Glass-Fiber Board Insulation: ASTM C 612, Type IA or ASTM C 553, Types I, II, and III; faced on 1 side with foil-scrim-kraft vapor retarder; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; and of the following nominal density and thermal resistivity:

1. Nominal density of 1.0 lb/cu. ft., thermal resistivity of 3.7 deg F x h x sq. ft. /Btu x in. at 75 deg F.
2. Nominal density of not less than 1.5 lb/cu. ft. nor more than 1.7 lb/cu. ft., thermal resistivity of 4 deg F x h x sq. ft./Btu x in. at 75 deg F.

D. Unfaced, Glass-Fiber Board Insulation: ASTM C 612, Type IA or Types IA and IB; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics; and of the following nominal density and thermal resistivity:

1. Nominal density of 2.25 lb/cu. ft., thermal resistivity of 4.3 deg F x h x sq. ft. /Btu x in. at 75 deg F.

2.3 INSULATION FASTENERS

A. Adhesively Attached, Prong-Type Anchors: Plate welded to projecting prong; capable of holding insulation of thickness indicated securely in position indicated with slotted washer in place; and complying with the following requirements:

1. Available Products:

a. AGM Industries, Inc.; Series PIH Insul-Hangers.

2. Plate: Perforated galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
3. Prong: Galvanized carbon steel; length to suit depth of insulation indicated.

B. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates indicated without damaging insulation, fasteners, and substrates.

1. Available Products:

a. AGM Industries, Inc.; TACTOO Adhesive.
b. Eckel Industries of Canada; Stic-Klip Type S Adhesive.
c. Gemco; Tuff Bond Hanger Adhesive.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements of Sections in which substrates and related work are specified and for other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean substrates of substances harmful to insulation or vapor retarders, including removing projections capable of puncturing vapor retarders or of interfering with insulation attachment.

3.3 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products and application indicated.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed at any time to ice, rain, and snow.

C. Extend insulation in thickness indicated to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

D. Water-Piping Coordination: If water piping is located within insulated exterior walls, coordinate location of piping to ensure that it is placed on warm side of insulation and insulation encapsulates piping.

E. For preformed insulating units, provide sizes to fit applications indicated and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units to produce thickness indicated unless multiple layers are otherwise shown or required to make up total thickness.

3.4 INSTALLATION OF PERIMETER AND UNDER-SLAB INSULATION

A. On vertical surfaces, set insulation units in adhesive applied according to manufacturer's written instructions. Use adhesive recommended by insulation manufacturer.

1. If not otherwise indicated, extend insulation a minimum of 24 inches below exterior grade line.

B. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

C. Protect below-grade insulation on vertical surfaces from damage during backfilling by applying protection course with joints butted. Set in adhesive according to insulation manufacturer's written instructions.

D. Protect top surface of horizontal insulation from damage during concrete work by applying protection course with joints butted.

3.5 INSTALLATION OF CAVITY-WALL INSULATION

A. On units of foam-plastic board insulation, install pads of adhesive spaced approximately 24 inches o.c. both ways on inside face, and as recommended by manufacturer. Fit courses of insulation between wall ties and other obstructions, with edges butted tightly in both directions. Press units firmly against inside substrates indicated.

1. Supplement adhesive attachment of insulation by securing boards with two-piece wall ties designed for this purpose and specified in Section 04 20 00 "UNIT MASONRY."

B. Install units of cellular-glass insulation with closely fitting joints using method indicated:

1. Gob Method: Apply 4 gobs of adhesive per unit and set units firmly against inside wythe of masonry or other construction as shown. Apply gobs at each corner; spread gobs to form pads 4 inches in diameter by 1/4 inch thick.
2. Serrated-Trowel Method: Apply adhesive to entire surface of each cellular-glass insulation unit with serrated trowel complying with insulation manufacturer's written instructions.
3. Coat edges of insulation units with full bed of adhesive to seal joints between insulation and between insulation and adjoining construction.
4. Coat exterior face (cold face) of installed cellular-glass block insulation course with asphalt coating.

3.6 INSTALLATION OF GENERAL BUILDING INSULATION

A. Apply insulation units to substrates by method indicated, complying with manufacturer's written instructions. If no specific method is indicated, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.

B. Seal joints between foam-plastic insulation units by applying adhesive, mastic, or sealant to edges of each unit to form a tight seal as units are shoved into place. Fill voids in completed installation with adhesive, mastic, or sealant as recommended by insulation manufacturer.

C. Set vapor-retarder-faced units with vapor retarder in location indicated of construction, unless otherwise indicated.

1. Tape joints and ruptures in vapor retarder, and seal each continuous area of insulation to surrounding construction to ensure airtight installation.

D. Install mineral-fiber insulation in cavities formed by framing members according to the following requirements:

1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill cavity, provide lengths that will produce a snug fit between ends.
2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
3. Maintain 3-inch clearance of insulation around recessed lighting fixtures.
4. Install eave ventilation troughs between roof framing members in insulated attic spaces at vented eaves.
5. For metal-framed wall cavities where cavity heights exceed 96 inches, support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.

   a. With faced blankets having stapling flanges, lap blanket flange over flange of adjacent blanket to maintain continuity of vapor retarder once finish material is installed over it.

E. Install board insulation on concrete substrates by adhesively attached, prong-type insulation anchors as follows:

1. Fasten insulation anchors to concrete substrates with insulation anchor adhesive according to anchor manufacturer's written instructions. Space anchors according to insulation manufacturer's written instructions for insulation type, thickness, and application indicated.
2. Apply insulation standoffs to each prong to create cavity width indicated between concrete substrate and insulation.
3. After adhesive has dried, install board insulation by pressing insulation into position over prongs and securing it tightly placing slotted insulation-retaining washers, and folding prongs to retain, taking care not to compress insulation below indicated thickness.

3.7 INSTALLATION OF INSULATION IN CEILINGS FOR SOUND ATTENUATION

A. Install 3-inch- thick, unfaced glass-fiber blanket insulation over suspended ceilings at partitions in a width that extends insulation 48 inches on either side of partition.

3.8 INSTALLATION OF VAPOR RETARDERS

A. General: Extend vapor retarder to extremities of areas to be protected from vapor transmission. Secure in place with adhesives or other anchorage system as indicated. Extend vapor retarder to cover miscellaneous voids in insulated substrates, including those filled with loose-fiber insulation.

B. Seal vertical joints in vapor retarders over framing by lapping not less than two wall studs. Fasten vapor retarders to wood framing at top, end, and bottom edges; at perimeter of wall openings; and at lap joints. Space fasteners 16 inches o.c.

C. Before installing vapor retarder, apply urethane sealant to flanges of metal framing including runner tracks, metal studs, and framing around door and window openings. Seal overlapping joints in vapor retarders with vapor-retarder tape according to vapor-retarder manufacturer's written instructions. Seal butt joints with vapor-retarder tape. Locate all joints over framing members or other solid substrates.

D. Firmly attach vapor retarders to metal framing and solid substrates with vapor-retarder fasteners as recommended by vapor-retarder manufacturer.

E. Seal joints caused by pipes, conduits, electrical boxes, and similar items penetrating vapor retarders with vapor-retarder tape to create an airtight seal between penetrating objects and vapor retarder.

F. Repair tears or punctures in vapor retarders immediately before concealment by other work. Cover with vapor-retarder tape or another layer of vapor retarder.

3.9 PROTECTION

A. Protect installed insulation and vapor retarders from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION 07 21 00

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SECTION 07 42 13 - METAL WALL PANELS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vertical metal wall panel assembly with integral reveals and profiled panels, and related trim and accessories.

1.2 REFERENCES

A. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 259	Standard Test Method for Potential Heat of Building Materials
NFPA 268	Standard Test Method for Determining Ignitability of Exterior Wall Assemblies Using a Radiant Heat Energy Source
NFPA 285	Standard Fire Text Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components.

B. AMERICAN SOCIETY FOR TESTING MATERIALS

ASTM E-34	Standard Test Methods for Chemical Analysis of Aluminum and Aluminum – Base Alloys

1.3 DEFINITION

A. Metal Wall Panel Assembly: Metal wall panels, attachment system components, miscellaneous metal framing, and accessories necessary for a complete weathertight wall system.

1.4 PERFORMANCE REQUIREMENTS

A. General Performance: Metal wall panel assemblies shall comply with performance requirements without failure due to defective manufacture, fabrication, installation, or other defects in construction. Walls will comply with the high velocity hurricane zone of the Florida Building Code as a minimum. Other performance requirements are set forth below. Provide evidence of product current Notice of Acceptance (NoA) per Miami-Dade County Building Code Compliance Office requirements. See Drawings for additional details.

B. Delegated Design: Design metal wall panel assembly, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Air Infiltration: Air leakage through assembly of not more than 0.06 cfm/sq. ft. of wall area when tested according to ASTM E 283 at the following test-pressure difference:

1. Test-Pressure Difference: 1.57 lbf/sq. ft.

D. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft.

E. Water Penetration under Dynamic Pressure: No evidence of water leakage when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft. And not more than 12 lbf/sq. ft.

1. Water Leakage: As defined according to AAMA 501.1.
2. Water Leakage: Uncontrolled water infiltrating the system or appearing on systems normally exposed interior surfaces from sources other than condensation. Water controlled by flashing and gutters that is drained back to the exterior and cannot damage adjacent materials or finishes is not water leakage.

F. Structural Performance: Provide metal wall panel assemblies capable of withstanding the effects the following loads and stresses within limits and under conditions indicated, based on testing according to ASTM E 1592:

1. Wind Loads: Determine loads based on the following minimum design wind pressures:

   a. + 75 psf, -103 psf

2. Deflection Limits: Metal wall panel assemblies shall withstand wind loads with horizontal deflections no greater than 1/240 of the span.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

H. Fire Performance Characteristics: Provide metal composite wall systems with the following fire-test characteristics determined by indicated test standard as applies by UL or other testing and inspection agency acceptable to authorities having jurisdiction.

1. Surface-Burning Characteristics: Provide metal composite wall system panels with the following characteristics when tested per ASTM E 84 or UL 723.a. Flame spread index: 25 or less.b. Smoke developed index: 450 or less.
2. Fire Performance of Insulated Wall: Third Party Design Listing CSG/GWP 30-03.
3. Room Corner Test: NFPA 285
4. Intermediate Scale Multistory Fire Test: Representative Mockup tested per NFPA 285.

5. Fire Resistance Ratings: Where indicated by design designations, provide metal wall panels tested per ASTM E 119; or UL 263, UL Fire Resistance, and UL Bld Mat Dir

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of wall panel and accessory.

B. Shop Drawings: Show fabrication and installation layouts of metal wall panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details. Distinguish between factory-, shop- and field-assembled work.

1. Accessories: Include details of the following items, at a scale of not less than 1-1/2 inches per 12 inches:

a. Flashing and trim.
b. Anchorage systems.

C. Samples for Initial Selection: For each type of metal wall panel indicated with factory-applied color finishes.

1. Include similar Samples of trim and accessories involving color selection.
2. Include manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each sealant exposed to view.

D. Delegated-Design Submittal: For metal wall panel assembly indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

E. Coordination Drawings: Exterior elevations drawn to scale and coordinating penetrations and wall-mounted items. Show the following:

1. Wall panels and attachments.
2. Penetrations of wall by pipes and utilities.

F. Qualification Data: For Installer and testing agency.

G. Material Certificates: For vapor retarders, signed by manufacturers.

H. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each product.

I. Field quality-control reports.

J. Maintenance Data: For metal wall panels to include in maintenance manuals.

K. Warranties: Sample of special warranties.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

B. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

C. Source Limitations: Obtain each type of metal wall panel from single source from single manufacturer.

D. Preinstallation Conference: Conduct conference at jobsite.

1. Meet with FAA, COR, FAA's insurer if applicable, testing and inspecting agency representative, metal wall panel Installer, metal wall panel manufacturer's representative, structural-support Installer, and installers whose work interfaces with or affects metal wall panels, including installers of doors, windows, and louvers.
2. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
3. Review methods and procedures related to metal wall panel installation, including manufacturer's written instructions.
4. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.
5. Review flashings, special siding details, wall penetrations, openings, and condition of other construction that will affect metal wall panels.
6. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
7. Review temporary protection requirements for metal wall panel assembly during and after installation.
8. Review wall panel observation and repair procedures after metal wall panel installation.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, sheets, metal wall panels, and other manufactured items so as not to be damaged or deformed. Package metal wall panels for protection during transportation and handling.

B. Unload, store, and erect metal wall panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal wall panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal wall panels to ensure dryness, with positive slope for drainage of water. Do not store metal wall panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal wall panel for period of metal wall panel installation.

1.8 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal wall panels to be performed according to manufacturers' written instructions and warranty requirements.

B. Field Measurements: Verify locations of structural members and wall opening dimensions by field measurements before metal wall panel fabrication, and indicate measurements on Shop Drawings.

1.9 COORDINATION

A. Coordinate metal wall panel assemblies with rain drainage work, flashing, trim, and construction of studs, soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal wall panel assemblies that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including rupturing, cracking, or puncturing.
b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion for materials. One year from date of sub comp. for workmanship.

3. Special Warranty to cover marine environments.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal wall panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

3. Special Warranty on panel finishes to cover marine environments.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design Product: CENTRIA Total Cad MW, Concealed Fastener Profiles or comparable product by one of the following:

1. Alply
2. Butler
3. Protean
4. Metl Span
5. Industrial Building Panels

B. Contractors that are using materials supplied by a manufacturer other than Centria shall list the material supplier/manufacturer of the metal walls panels, provide a sample of the panel including a complete side joint with clip, and provide a letter signed and sealed by a professional engineer registered in the jurisdiction of the project indicating that the proposed products meet or exceed specified requirements.

2.2 METAL WALL PANELS

A. Basis of Design panel system complies with NFPA 285 based on Intertek Design #CSG/CWP 30-03, revised 2/15/2018. Any alternate panel must be tested and test results shall be submitted for review. Insulation Material shall have been successfully tested by NFPA 259 in accordance with IBC Section 2603.

B. Panel System Product:

1. Panel Thickness: 1.5 inches
2. Panel Width: 12 inches
3. Vertical wall panel system consisting of a metal sheet with factory sealed tongue-and-groove vertical joint, and attached to supports using concealed fasteners.
4. Panel Sealant/Vapor Seal: Factory-applied non-curing butyl.

2.3 MATERIALS

A. Metallic-Coated Steel Face Sheet, Coil Coated: ASTM A 755/A 755M.

1. Zinc-Coated (Galvanized) Steel Face Sheet: ASTM A 653/A 653M, G90, structural quality.
    a. Finish: Standard fluoropolymer two-coat system consisting of 0.2 mil primer with 0.8 mil 70 percent PVDF fluoropolymer color coat. Color to be selected from manufacturer’s standard.

2.4 ACCESSORIES

A. Metal Wall Panel Accessories:

1. Provide complete metal wall panel assembly including trim, copings, fascia, parapet caps, soffits, sills, inside and outside corners, jambs, and miscellaneous flashings. Include required fasteners, gaskets, closure strips, and sealants.
2. Fabricate all accessories to be compatible with specified metal panels.
3. Finish exposed trim and extrusions to match panels.

2.5 MISCELLANEOUS MATERIALS

A. Sealant: Synthetic non-skinning butyl rubber sealant, as recommended by panel manufacturer, for metal wall panel assemblies to remain watertight.

B. Fasteners: Self-tapping screws, bolts, nuts, and other acceptable fasteners recommended by panel manufacturer. Where exposed fasteners cannot be avoided, supply corrosion-resistant fasteners with heads matching color of metal wall panels by means factory-applied coating.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal wall panel supports, and other conditions affecting performance of work.
   1. Examine existing wall to verify that wall joints are supported by framing or blocking and that installation is within flatness tolerances required by metal wall panel manufacturer.
   2. Clean the existing wall panels prior to new wall installation
   3. All areas of rust on existing wall panels shall be coated with zinc rich primer prior to new wall installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Miscellaneous Framing: Install subgirts, base angles, sills, furring, and other miscellaneous wall panel support members and anchorages according to ASTM C 754 and metal wall panel manufacturer's written recommendations.

   1. Soffit Framing: Wire-tie or clip furring channels to supports, as required to comply with requirements for assemblies indicated.

3.3 METAL WALL PANEL INSTALLATION

A. General: Install metal wall panels according to manufacturer's written instructions in orientation, sizes, and locations indicated on Drawings. Install panels vertically unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Commence metal wall panel installation and install minimum of 300 sq. ft. in presence of factory-authorized representative.
2. Shim or otherwise plumb substrates receiving metal wall panels.
3. Flash and seal metal wall panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until weather barrier and flashings that will be concealed by metal wall panels are installed.
4. Install screw fasteners in predrilled holes.
5. Locate and space fastenings in uniform vertical and horizontal alignment.
6. Install flashing and trim as metal wall panel work proceeds.
7. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
8. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete and elsewhere as indicated or, if not indicated, as necessary for waterproofing.
9. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
10. Provide weathertight escutcheons for pipe and conduit penetrating exterior walls.

B. Fasteners:

1. Steel Wall Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized steel fasteners for surfaces exposed to the interior.

C. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action as recommended by metal wall panel manufacturer.

D. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weathertight performance of metal wall panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by metal wall panel manufacturer.

1. Seal metal wall panel end laps with double beads of tape or sealant, full width of panel. Seal side joints where recommended by metal wall panel manufacturer.
2. Prepare joints and apply sealants to comply with requirements in Section 07 96 00 "JOINT SEALANTS”.

3.4 ACCESSORY INSTALLATION

A. General: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal wall panel assembly including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.

B. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Water Penetration: Test areas of installed system indicated on Drawings for compliance with system performance requirements according to ASTM E 1105 at minimum differential pressure of 20 percent of inward-acting, wind-load design pressure as defined by SEI/ASCE 7, but not less than 6.24 lbf/sq. ft.

C. Water-Spray Test: After completing the installation of 75-foot- by-2-story minimum area of metal wall panel assembly, test assembly for water penetration according to AAMA 501.2 in a 2-bay area directed by COR.

D. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect and test completed metal wall panel installation, including accessories.

E. Remove and replace metal wall panels where tests and inspections indicate that they do not comply with specified requirements.

F. Additional tests and inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.6 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal wall panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal wall panel installation, clean finished surfaces as recommended by metal wall panel manufacturer. Maintain in a clean condition during construction.

B. After metal wall panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

C. Replace metal wall panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 42 13

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SECTION 07 54 19 - POLYVINYL CHLORIDE (PVC) MEMBRANE ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Adhered PVC membrane roofing system.
2. Roof insulation.
3. Cover board.
4. Vapor retarder.
5. Paver protection mat.

1.2 DEFINITIONS

A. Roofing Terminology: Definitions in ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" apply to work of this Section.

1.3 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work, including:

1. Base flashings and membrane terminations.
2. Tapered insulation, including slopes.
3. Crickets, saddles, and tapered edge strips, including slopes.

C. Samples for Verification: For the following products:

1. Sheet roofing, of color required.
2. Walkway pads or rolls, of color required.
3. Roof insulation.
4. Cover boards.
5. Vapor retarder.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer that is UL listed for roofing system identical to that used for this Project.

B. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

1. Submit evidence of compliance with performance requirements.

C. Product Test Reports: For components of roofing system, tests performed by manufacturer and witnessed by a qualified testing agency.

D. Field quality-control reports.

E. Sample Warranties: For manufacturer's special warranties.

F. Closeout Submittals

1. Maintenance Data: For roofing system to include in maintenance manuals.

G. Test Reports:

1. Roof drain and leader test or submit plumber’s verification.
2. Core cut (if requested).

H. Source Limitations: Obtain all components from the single source roofing system manufacturer guaranteeing the roofing system. All products used in the system shall be labeled by the single source roofing system manufacturer issuing the guarantee.

I. Pre-installation Meetings:

1. Preliminary Roofing Conference: Before starting roof deck construction, conduct conference at Project site.
   a. Meet with Owner, Architect, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
   b. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
   c. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
   d. Review deck substrate requirements for conditions and finishes, including flatness and fastening.
   e. Review structural loading limitations of roof deck during and after roofing.
   f. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
   g. Review governing regulations and requirements for insurance and certificates if applicable.
   h. Review temporary protection requirements for roofing system during and after installation.
   i. Review roof observation and repair procedures after roofing installation.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.

1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.

D. Handle and store roofing materials, and place equipment in a manner to avoid permanent deflection of deck.

1.6 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Special warranty includes roofing, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, and other components of roofing system.
2. Warranty Period: 20 years from date of Substantial Completion.

B. Special Project Warranty: Submit roofing Installer's warranty, on warranty form at end of this Section, signed by Installer, covering the Work of this Section, including all components of roofing system such as roofing, base flashing, roof insulation, fasteners, cover boards, substrate boards, vapor retarders, roof pavers, and walkway products, for the following warranty period:

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 POLYVINYL CHLORIDE ROOFING MEMBRANE - PVC

A. PVC Sheet: ASTM D 4434, Type III, fabric reinforced that contains KEE (Elvaloy) to reduce plasticizer migration.

1. Certification, by letter, stating that the formulation has a minimum 15 years of performance history in North America.
2. Thickness: 60mm.

2.2 AUXILIARY ROOFING MATERIALS – SINGLE PLY

A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with membrane roofing.

1. Liquid-type auxiliary materials shall meet VOC limits of authorities having jurisdiction.

B. Sheet Flashing: Manufacturer's sheet flashing of same material, type, reinforcement, thickness, and color as sheet membrane.

C. Sheet Flashing: Manufacturer's unreinforced sheet flashing of same material as sheet membrane.

D. Bonding Adhesive: Manufacturer's standard solvent-based bonding adhesive for membrane, and solvent-based bonding adhesive for base flashings.

E. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.

F. Metal Termination Bars: Manufacturer's standard predrilled stainless-steel or aluminum bars, with anchors.

G. Metal Battens: Manufacturer's standard aluminum-zinc-alloy-coated or zinc-coated steel sheet, prepunched.

H. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FMG 4470, designed for fastening membrane to substrate, and acceptable to membrane roofing system manufacturer.

I. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, termination reglets, cover strips, sealants, and other accessories.

2.3 AUXILIARY ROOFING System Components

A. Expansion Joints: Provide factory fabricated weatherproof, exterior covers for expansion joint openings consisting of flexible rubber membrane, supported by a closed cell foam to form flexible bellows, with two metal flanges, adhesively and mechanically combined to the bellows by a bifurcation process.

B. Coping System: Manufacturer’s factory fabricated coping consisting of a base piece and a snap-on cap.

C. Metal Flashing Sheet: Metal flashing sheet is specified in Division 07 Section "Sheet Metal Flashing and Trim."

2.4 WALKWAYS

A. Flexible Walkways: Factory-formed, nonporous, heavy-duty, slip-resisting, surface-textured walkway pads sourced from membrane roofing system manufacturer.

2.5 COVER BOARD

A. High-Density Polyisocyanurate: High-density polyisocyanurate technology bonded in-line to mineral-surfaced, fiber glass reinforced facers with greater than 125 lbs. of compressive strength.

2.6 ROOF INSULATION

A. General: Provide preformed roof insulation boards that comply with requirements and referenced standards, selected from manufacturer's standard sizes and of thicknesses indicated.

B. Polyisocyanurate Board Insulation: ASTM C 1289, Type II.

2.7 TAPERED INSULATION

A. Tapered Insulation: ASTM C 1289, provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches, unless otherwise indicated.

2.8 INSULATION ACCESSORIES

A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatible with membrane roofing.

B. Provide factory preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

C. Urethane Adhesive: Manufacturer’s two component urethane adhesive formulated to adhere insulation to substrate.

2.9 VAPOR RETARDER

A. Polyethylene Air Barrier: ASTM D 4397, 6 mils thick, minimum, with maximum permeance rating of 0.13 perm.

1. Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
2. Adhesive: Manufacturer's standard lap adhesive, FMG approved for vapor-retarder application.

2.10 PAVER PROTECTION MAT OR SLIPSHEET

A. Polyester Mat Protection Slip-sheet intended for use as a separation layer between roofing membrane and paver blocks in protected membrane (inverted) roof assemblies. Membrane shall be a minimum 9.0 ounce needle punched, UV-resistant polyester fabric.

2.11 MANUFACTURERS

A. Source Limitations: Obtain components including roof insulation and fasteners for roofing system from manufacturer as membrane roofing or manufacturer approved by membrane roofing manufacturer.

2.12 PERFORMANCE REQUIREMENTS

A. General Performance: Installed roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roofing and base flashings shall remain watertight.

1. Accelerated Weathering: Roofing system shall withstand 2000 hours of exposure when tested according to ASTM G 152, ASTM G 154, or ASTM G 155.
2. Impact Resistance: Roofing system shall resist impact damage when tested according to ASTM D 3746 or ASTM D 4272.

B. Material Compatibility: Roofing materials shall be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roofing manufacturer based on testing and field experience.

C. FM Global Listing: Roofing, base flashings, and component materials shall comply with requirements in FM Global 4450 or FM Global 4470 as part of a built-up roofing system, and shall be listed in FM Global's "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.

1. Fire/Windstorm Classification: Class 1A-90.
2. Hail-Resistance Rating:SH.

D. Energy Star Listing: Roofing system shall be listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work:

1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
3. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Section 053100 "Steel Decking."
4. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
5. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
6. Verify that concrete-curing compounds that will impair adhesion of roofing components to roof deck have been removed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.

B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.

C. Install insulation strips according to acoustical roof deck manufacturer's written instructions.

1. Remove an area no larger than can be re-roofed in one day.

D. Tear out all base flashings, counterflashings, pitch pans, pipe flashings, vents, and like components necessary for application of new membrane.

E. Remove abandoned equipment curbs, skylights, smoke hatches, and penetrations.

1. Install decking to match existing as directed by Owner's Representative.

F. Raise (disconnect by licensed craftsmen, if necessary) all HVAC units and other equipment supported by curbs to conform with the following:

1. Modify curbs as required to provide a minimum 8" base flashing height measured from the surface of the new membrane to the top of the flashing membrane.
2. Nail top of flashing and install new metal counterflashing prior to re-installation of unit.
3. Perimeter nailers must be elevated to match elevation of new roof insulation.

G. Immediately remove all debris from roof surface. Demolished roof system may not be stored on the roof surface.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 RECOVER PREPARATION

A. Prepare existing roof according to roofing system manufacturer's written instructions, applicable recommendations of the roofing manufacturer, and requirements in this Section.

B. Tear out all base flashings, counterflashings, pitch pans, pipe flashings, vents, and like components necessary for application of new membrane.

C. Disable existing roof membrane by cutting a minimum 5 foot x 5 foot grid pattern.

D. “Skin” existing membrane at substrate.

E. Remove existing membrane at fasteners.

F. Remove and replace wet, deteriorated or damaged roof insulation and decking as identified in moisture survey.

G. Remove abandoned equipment curbs, skylights, smoke hatches, and penetrations. Install decking to match existing as directed by Owner's Representative.

H. Raise, (disconnect by licensed craftsmen, if necessary) all HVAC units and other equipment supported by curbs to conform with the following:

1. Modify curbs as required to provide a minimum 8" base flashing height measured from the surface of the new membrane to the top of the flashing membrane.
2. Nail top of flashing and install new metal counterflashing prior to re-installation of unit.
3. Perimeter nailers must be elevated to match elevation of new roof insulation.

I. Immediately remove all debris from roof surface. Demolished roof system may not be stored on the roof surface.

J. Prime existing cap sheet to prepare for recover application.

K. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 VAPOR-RETARDER INSTALLATION

A. Install polyethylene-sheet vapor retarder as a loosely laid single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 inches and 6 inches, respectively.

1. Seal side and end laps with adhesive.

B. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.5 INSULATION INSTALLATION

A. Coordinate installation of roof system components so insulation and cover board is not exposed to precipitation or left exposed at the end of the workday.

B. Comply with roofing system manufacturer's written instructions for installation of roof insulation and cover board.

C. Install tapered insulation under area of roofing to conform to slopes indicated.

D. Install insulation boards with long joints in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch with like material.

E. Trim surface of insulation boards where necessary at roof drains so completed surface is flush and does not restrict flow of water.

F. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.

G. Adhered Insulation: Install each layer of insulation and cover board and adhere to substrate as follows:

1. Install each layer in a two-part urethane adhesive according to roofing system manufacturer’s instruction.
2. Install each layer in a solid mopping of hot roofing asphalt according to roofing system manufacturer’s instruction.
3.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.6 COVER BOARD INSTALLATION

A. Coordinate installing membrane roofing system components so cover board is not exposed to precipitation or left exposed at the end of the workday.

B. Comply with membrane roofing system manufacturer's written instructions for installing roof cover board.

C. Install cover board with long joints of cover board in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with cover board.

1. Cut and fit cover board within 1/4 inch (6 mm) of nailers, projections, and penetrations.

D. Trim surface of cover board where necessary at roof drains so completed surface is flush and does not restrict flow of water.

1. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.

E. Adhered Cover Board: Adhere cover board to substrate as follows:

1. Install in a solid mopping of hot roofing asphalt according to roofing system manufacturer’s instruction.
2. Install in a two-part urethane adhesive according to roofing system manufacturer’s instruction.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.7 ROOFING MEMBRANE INSTALLATION, GENERAL

A. Install roofing membrane in accordance with roofing system manufacturer's written instructions, applicable recommendations of the roofing manufacturer and requirements in this Section.

B. Start installation of roofing membrane in presence of roofing system manufacturer's technical personnel.

C. Where roof slope exceeds 1/2 inch per 12 inches (1:24, contact the membrane manufacturer for installation instructions regarding installation direction and backnailing

D. Cooperate with testing and inspecting agencies engaged or required to perform services for installing roofing system.

E. Coordinate installing roofing system so insulation and other components of the roofing membrane system not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is imminent.

1. Provide tie-offs at end of each day's work to cover exposed roofing membrane sheets and insulation with a course of coated felt set in roofing cement or hot roofing asphalt with joints and edges sealed.
2. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system.
3. Remove and discard temporary seals before beginning work on adjoining roofing.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.8 ADHERED ROOFING MEMBRANE INSTALLATION

A. Install roofing membrane over area to receive roofing in accordance with membrane roofing system manufacturer's written instructions. Unroll roofing membrane and allow to relax before installing.

1. Install sheet in accordance with ASTM D 5036 and roofing system manufacturer’s written instructions.

B. Start installation of roofing membrane in presence of membrane roofing system manufacturer's technical representative.

C. Accurately align roofing membrane and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

D. Bonding Adhesive: Apply solvent-based bonding adhesive to substrate and underside of roofing membrane at rate required by manufacturer and allow to partially dry before installing roofing membrane. Do not apply bonding adhesive to splice area of roofing membrane.

E. Bonding Adhesive: Apply water-based bonding adhesive to substrate at rate required by manufacturer and immediately install roofing membrane. Do not apply bonding adhesive to splice area of roofing membrane.

F. Asphalt Application: Adhere to substrate in a solid mopping of hot asphalt applied at not less than EVT.

1. Install membrane using either roll or fold method. Refer to Johns Manville Single Ply Binder for details.
2. “Broom” the sheet in to ensure full contact. Do not walk on membrane.

G. Urethane Membrane Adhesive: Apply 2-Part Urethane Adhesive substrate at rate required by manufacturer and install fleece-backed roofing membrane. Do not apply bonding adhesive to splice area of roofing membrane.

H. Mechanically fasten roofing membrane securely at terminations, penetrations, and perimeter of roofing.

I. Apply roofing membrane with side laps shingled with slope of roof deck where possible.

J. Adhesive Seam Installation: Clean both faces of splice areas, apply splicing cement, and firmly roll side and end laps of overlapping roofing membranes according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of roofing membrane terminations.

1. Apply a continuous bead of in-seam sealant before closing splice if required by membrane roofing system manufacturer.

K. Seams: Clean seam areas, overlap roofing membrane, and hot-air weld side and end laps of roofing membrane according to manufacturer's written instructions to ensure a watertight seam installation.

1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of roofing membrane.
2. Verify field strength of seams a minimum of twice daily and repair seam sample areas.

   a. Remove and repair any unsatisfactory sections before proceeding with Work.

3. Repair tears, voids, and lapped seams in roofing membrane that do not meet requirements.

L. Spread sealant or mastic bed over deck drain flange at deck drains and securely seal roofing membrane in place with clamping ring.

M. Install roofing membrane and auxiliary materials to tie in to existing roofing.

N. Proceed with installation only after unsatisfactory conditions have been corrected.

3.9 BASE FLASHING INSTALLATION

A. Install sheet flashings and preformed flashing accessories and adhere to substrates in accordance with membrane roofing system manufacturer's written instructions.

B. Apply solvent-based bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply bonding adhesive to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with sheet flashing.

D. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

E. Clean seam areas and overlap and firmly roll sheet flashings into the adhesive. Weld side and end laps to ensure a watertight seam installation.

F. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.10 WALKWAY INSTALLATION

A. Flexible Walkways: Install walkway products in locations indicated. Adhere with compatible adhesive and heat weld walkway products to substrate according to roofing system manufacturer's written instructions. – PVC

B. Roof-Paver Walkways: Install walkway roof pavers according to manufacturer's written instructions in locations indicated, to form walkways. Leave 3 inches of space between adjacent roof pavers.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.11 FIELD QUALITY CONTROL

A. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.

B. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.

C. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

3.12 PROTECTING AND CLEANING

A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07 54 19

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SECTION 07 57 00 - WATERPROOF DECK COATING

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

a.	ASTM C 501	Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser
b.	ASTM C 957	Standard Specification for High-Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with Integral Wearing Surface
c.	ASTM C 1127	Standard Guide for Use of High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with an Integral Wearing Surface
d.	ASTM E 108	Standard Test Methods for Fire Tests of Roof Coverings

2. UNDERWRITERS LABORATORIES, INC.

a.	UL 790	UL Standard for Safety Tests for Fire Resistance of Roof Covering Materials

1.2 SUBMITTALS

A. Manufacturer’s Catalog Data

1. Fluid-applied membrane (Base Coat, Intermediate Coat, Top Coat)
2. Primers (Concrete, Plywood, Metal)
3. Backer Rod
4. Sealant
5. Sheet Flashing
6. Flashing Reinforcement
7. Aggregate
8. Cleaning Agents
9. Fluid Applied Integral Flashing
10. Bond Breaker
11. Sample

B. Submit material description and physical properties, application details, and recommendations regarding shelf life, application procedures, and precautions on flammability and toxicity.

C. Product data:

1. Materials list of items proposed to be provided under this Section;
2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements;
3. Shop Drawings or catalog illustrations in sufficient detail to show installation and interface of the work of this Section with the work of adjacent trades;
4. Manufacturer's current recommended installation procedures which, when reviewed by Architect, will become the basis for accepting or rejecting actual installation procedures used on the Work.
5. Written documentation of applicator's qualifications, including reference projects of similar scope and complexity, with current phone contacts of architects and owners for verification.

1.3 PREWATERPROOFING CONFERENCE

A. Prior to starting application of waterproofing system, arrange and attend a prewaterproofing conference to ensure a clear understanding of drawings and specifications. Give the Contracting Officer 7 days advance written notice of the time and place of meeting. Ensure that the mechanical and electrical subcontractor, flashing and sheet metal subcontractor, and other trades that may perform other types of work on or over the membrane after installation, attend this conference.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver waterproofing materials in manufacturer’s original, unopened containers, with labels intact and legible. Containers of materials covered by a referenced specification number shall bear the specification number, type, and class of the contents. Deliver materials in sufficient quantity to continue work without interruption. Store and protect materials in accordance with manufacturer’s instructions, and use within their indicated shelf life. When hazardous materials are involved, adhere to special precautions of the manufacturer, unless precautions conflict with local, state, and federal regulations. Promptly remove from the site materials or incomplete work adversely affected by exposure to moisture or freezing. Store materials on pallets and cover from top to bottom with canvas tarpaulins.

1.5 ENVIRONMENTAL CONDITIONS

A. Apply materials when ambient temperature is 4 degrees C (40 degrees F) or above for a period of 24 hours prior to the application and when there is no surface moisture, or visible dampness on the substrate surface. Apply materials when air temperature is expected to remain above 4 degrees C (40 degrees F) during the cure period recommended by the manufacturer. Moisture test for substrate is specified under paragraph entitled “Moisture Test”. Work may be performed within heated enclosures, provided the surface temperature of the substrate is maintained at a minimum of 4 degrees C (40 degrees F) for 24 hours prior to the application of the waterproofing, and remains above that temperature during the cure period recommended by the manufacturer.

B. Provide positive ventilation, as required by manufacturer’s MSDS for interior applications. Supply positive ventilation until eight hours after application period.

C. Remove open fires and spark producing equipment from the application area until vapors have dissipated.

D. Post “No Smoking” signs in areas with limited ventilation.

1.6 SUBSTRATE CONDITIONS

A. General:

1. Provide applicator with surfaces that are broom clean, dry, sound and free of voids, bug holes, rock pockets, honeycombs, protrusions, excessive roughness, foreign matter, frost, ice and other contaminants which may inhibit application or performance of the waterproofing coating system.
2. Using suitable abrasive methods, remove residue of form release, curing compound, chemical retarders and other surface treatments, laitance, mortar smear, saw cutting residue, mill scale, rust, loose material and other contaminants from concrete, masonry and ferrous metal surfaces to receive the work of this Section.

B. Concrete: Where work of this Section will be applied to concrete, provide surfaces that are smooth with finish equal to one that is light steel troweled followed by a fine hair broom.

C. Plywood: Where work of this Section will be applied to plywood.

D. Decks:

1. Slope deck surfaces to drains that have flanges at coating level which are flush with deck surfaces.
2. Rigidly install pipe, vents and other surface protrusions, properly flash them, and cover to prevent entry of coating materials.

E. Metal flashings: Where metal flashings are substrate to waterproofing coating, set the flashings in continuous bedding bead of urethane sealant; install sealant S-bead between metal laps and mechanically fasten to substrate along leading edges at every 4" on center, staggered linearly, to lay flat without fish mouths.

F. Joints: Configuration shall be consistent with this Section and with all other requirements of the Contract Documents.

1.7 QUALITY ASSURANCE

A. Applicator: Shall be experienced in successfully applying the fluid-applied membrane with a minimum of five years experience and shall be licensed by the manufacturer.

B. Field Sample: Submit sample not less than 4" x 3" of products to be applied at the project site representative of the installed system. Sample shall be used as a reference during the project.

1.8 WARRANTY

A. Upon completion, on a single document, provide a copy of written guarantee from the fluid-applied manufacturer and the applicator, against defects of materials and workmanship, for a period of five years, beginning with date of government acceptance of the building not date of completion of the deck coating system.

PART 2 - PRODUCTS

2.1 FLUID-APPLIED MEMBRANE

A. ASTM C 957. The cured membrane shall have an abrasion resistance of no more than 0.001 in loss as test in accordance with ASTM C 501 using C517 wheel, 1000 cycles with 1000-gram weight. The system shall be fire rated Class "A" on non-combustible substrate as tested per ASTM E 108 or UL 790. The system shall consist of a base coat, intermediate coat, and topcoat. The top coat shall provide excellent ultraviolet protection.

B. Provide a complete liquid applied polyurethane waterproofing coating system having the following minimum attributes:

1. System designed for waterproofing decks subject to pedestrian traffic;
2. Complying with ASTM C957-91 and having a Class A fire rating on concrete substrates.
3. Color to be selected by COR from manufacturer's standard color range.
4. Acceptable products:
5. Vulkem 360NF/951NF - This system is low VOC and fast cure and tougher meeting ASTM C957. As discussed, it is more expensive but the small area would make it the product of choice or prior approved equal

2.2 MEMBRANE PRIMER

A. As recommended by the fluid-applied membrane manufacturer for use on the appropriate substrate.

2.3 SEALANT

A. Low modulus, unmodified polyurethane or polysulfide based or as recommended by the fluid-applied membrane manufacturer.

2.4 SEALANT PRIMER

A. As recommended by the manufacturer of the type sealant to be used.

2.5 SEALANT

A. Sealant:

1. Dymeric 240-FC
2. Vulkem 116

2.6 BACKING MATERIAL

A. Premolded, closed-cell, polyethylene foam rod having a diameter 25 percent larger than joint width before being compressed into joint. Provide bond breaker of polyethylene film or other suitable materials between backing material and sealant.

2.7 BOND BREAKER

A. As recommended by the fluid-applied membrane manufacturer. Bond breaker shall not interfere with the curing process or other performance properties of the fluid-applied membrane.

2.8 SHEET FLASHING

A. 0.050-inch thick, precured, commercial grade neoprene.

2.9 FLASHING REINFORCEMENT

A. Non-woven, uncoated fiberglass mesh.

2.10 AGGREGATE

A. Aggregate: 40-50 mesh silica sand; local aggregate approved by coating manufacturer

2.11 CLEANING AGENTS

A. Toulene, 1, 1,1, trichloroethane or xylene or as recommended by the fluid-applied membrane manufacturer.

2.12 FLUID APPLIED INTEGRAL FLASHING

A. As recommended by the fluid applied membrane manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate work with that of other trades to ensure that components to be incorporated into the waterproofing system are available when needed. Inspect and approve surfaces immediately before application of waterproofing materials.

B. Concrete Conditions: Before coating is applied, inspect the top surface of the substrate and treat as necessary to remove laitance, loose material on the surface, grease, oil, and other contaminants which will affect bond of the coating.

C. Concrete surfaces shall be visibly dry and pass a 4-hour rubber mat test (no condensation) prior to application of the coating system.

D. Verify that curing methods used for concrete are compatible with the top surface requirements for the deck coating system.

E. Commencement of coating installation implies acceptance of the top surface of the substrate area only, as suitable to accept deck coating system.

F. Plywood Conditions: Plywood decks shall be dry, clean, and sound and fastened with non-rusting screws and glue. The surface of the deck shall be free of voids and offsets at joints. Ensure that all screw heads are flush with deck surface. Plywood edges shall be tongue and groove and supported on solid lumber framing or blocking to prevent differential deflection.

G. Metal Conditions: Metal surfaces shall be dry, clean, free of grease, oil, dirt, rust and corrosion and other coatings and contaminants which could affect bond of the coating system and without unusual sharp projections or edges.

H. Preparation: Thoroughly clean all surfaces to receive coating materials in accordance with manufacturer's instructions and recommendations. Remove oil and grease with a commercial grade alkaline cleaner; thoroughly rinse and dry. Prepare all concrete surfaces by sandblasting, power blast, and acid etching with a 10-15% solution of muriatic acid or high-pressure wash (min. 2000 psi). (Caution: Use adequate respiratory, eye and skin protection when using etching solutions, sandblasting, or power blasting). Flush all acid with clean water and allow to dry. Treat top surfaces, other than concrete, as recommended by manufacturer.

I. Treat all expansion, control and construction joints to be over coated by deck coating with sealant. Joints wider than one inch should not be coated.

J. Protect adjacent surfaces with drop cloths or masking as required.

K. Prime all concrete, masonry and metal following manufacturer's recommendations.

L. Apply 40-mil dry film thickness of non-flow type base coat over all flashings (sheet flashings, sealant coves and rigid corners). Extend coating 2 inches beyond flashing, out onto adjacent deck surface. Unless otherwise indicated on drawings or where limited by height of base, extend coating a minimum of 2 inches above the top of the flashing and terminate in a straight line. Use masking tape for such purposes.

M. Rout or saw-cut cracks exceeding 1/16 inch in width and fill with sealant. Apply 40-mil dry film thickness of non-flow type base coat for a distance of 2 inches on each side of all cracks.

N. Apply 40-mil dry film thickness of non-flow type base coat for a distance of 2 inches on each side of all expansion joints, control joints and construction joints to be coated.

O. Plywood Preparation: Inspect top surface and treat in accordance with manufacturer's recommendations.

P. Sweep, blow, or vacuum clean all surfaces to be coated.

Q. Plywood surface must be dry.

R. At all sealant coves, apply a 20-mil dry film thickness of non-flow type base coat. Extend coating to a distance of 2 inches beyond the sealant cove, out onto the adjacent deck surface. Unless otherwise indicated on the project drawings, extend coating a minimum distance of 2 inches up the vertical surface above the sealant cove and terminate in a neat, straight line. Use masking tape for such purposes.

S. Metal Preparation: Apply 40-mil dry film thickness of non-flow type base coat over all lap joints and bolts for a distance of 2-inches.

T. Prime metal surface following manufacturer's recommendations.

U. Flashings: Make penetrations through sleeves in concrete slab watertight before application of waterproofing. After flashing is completed, cover elastomeric sheet with fluid-applied waterproofing during waterproofing application.

1. Drains: Make drain flanges flush with surface of structural slab. Apply a full elastomeric sheet around the drain, with edges fully adhered to drain flange and to structural slab. Do not adhere elastomeric sheet over joint between drain and concrete slab. Do not plug drainage or weep holes. Cover elastomeric sheet with fluid-applied waterproofing during waterproofing application. Lap elastomeric sheet a minimum of 100 mm (4 inches) onto horizontal deck.
2. Penetrations and Projections: Flash penetrations and projections through structural slab with an elastomeric sheet adhered to the concrete slab and the penetration. Leave elastomeric sheet unadhered for 25 mm (one inch) over joint between penetration and concrete slab. Adhere elastomeric sheet a minimum of 100 mm (4 inches) onto horizontal deck.
3. Walls and Vertical Surfaces: Flash wall intersections which are not of monolithic pour or constructed with reinforced concrete joints with an elastomeric sheet adhered to both vertical wall surfaces and concrete slab. Flash intersections which are monolithically poured or constructed with reinforced concrete joints with either an elastomeric sheet or a vertical grade of fluid-applied waterproofing adhered to vertical wall surfaces and concrete slabs. Leave sheet unadhered for a distance of 25 mm (one inch) from the corner on both vertical and horizontal surfaces.

V. Cracks and Joints: Prepare visible cracks and joints in substrate to receive fluid-applied waterproofing membrane by placing a bond breaker and an elastomeric slip-sheet between membrane and substrate. Cracks that show movement shall receive a 50 mm (2 inch) bond breaker followed by an elastomeric sheet adhered to the deck. Nonmoving cracks shall be double coated with fluid-applied waterproofing.

3.2 SPECIAL PRECAUTIONS

A. Protect waterproofing materials during transport and application. Do not dilute primers and other materials, unless specifically recommended by materials manufacturer. Keep containers closed except when removing contents. Do not mix remains of unlike materials. Thoroughly remove residual materials before using application equipment for mixing and transporting materials. Do not permit equipment on the project site that has residue of materials used on previous projects. Use cleaners only for cleaning, not for thinning primers or membrane materials. Ensure that workers and others who walk on cured membrane wear clean, soft-soled shoes to avoid damaging the waterproofing materials.

3.3 APPLICATION

A. Base Coat

1. Apply coating material at a dry film thickness of 40 mils (minimum). Extend coating over all fluid applied flashings and detail coatings.
2. Allow to cure for 16 hours minimum. At temperatures less than 77 F (25 C) and relative humidities less than 50%, extend curing time.

B. Heavy Duty Intermediate Coat

1. Apply coating material at a dry film thickness of 25 mils to all 10 areas which have been base coated.
2. While coating is still fluid, uniformly broadcast Silicon Carbide at the rate of 10 lbs./100 sq. ft. over the surface. Immediately roll and back roll to evenly distribute and completely coat the aggregate.
3. Allow to cure 16 hours minimum. At temperatures less than 77 F (25 C) and relative humidities less than 50%, extend curing time.

C. Top Coat

1. Apply topcoat material at a dry film thickness of 12-13 mils to all areas which have been previously coated.
2. While coating is still fluid, uniformly broadcast Silicon Carbide over the surface at the rate of 5 pounds per 100 square feet. Immediately roll to evenly distribute and completely coat the aggregate.
3. Allow topcoat to cure 48 hours minimum before permitting traffic on surfaces. At temperatures less than 77 F (25 C) and relative humidities less than 50%, extend curing time.

3.4 FIELD QUALITY CONTROL

A. Moisture Test: Concrete surfaces shall be visibly dry and pass a four-hour rubber mat test (no condensation) prior to application of the coating system.

B. Film Thickness: Measure wet film thickness every 10 square meters (100 square feet) during application by placing flat metal plates on the substrate or using a mil-thickness gauge especially manufactured for the purpose.

3.5 CLEANING

A. Clean stains from adjacent surfaces with appropriate cleaning agents. Remove foreign matter from the finished coating surfaces.

3.6 INFORMATION CARD

A. Furnish a typewritten card containing information listed in the attached Form 1, framed in a watertight frame under clear glass or plastic for each waterproofing installation. Furnish framed card and duplicate card.

END OF SECTION 07 57 00

FORM 1 - FLUID-APPLIED WATERPROOFING SYSTEM COMPONENTS

1. Contract Number

2. Date Work Completed

3. Project Specification Designation

4. Substrate Material

5. Slope of Substrate

6. Drains Type/Manufacturer

7. Waterproofing

    a. Base Coat
    b. Intermediate Coat
    c. Top Coat
    d. Materials Manufacturer(s)

8. Wearing Surface Type
   Aggregate Type

9. Statement of Compliance or Exception

Contractor’s Signature Date Signed

Inspector’s Signature Date Signed

END OF FORM 1

SECTION 07 62 00 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manufactured Products:

   a. Manufactured through-wall flashing and counter flashing.
   b. Manufactured reglets and counter flashing.

2. Formed Products:

   a. Formed roof drainage sheet metal fabrications.
   b. Formed low-slope roof sheet metal fabrications.
   c. Formed steep-slope roof sheet metal fabrications.
   d. Formed wall sheet metal fabrications.
   e. Formed equipment support flashing.
   f. Formed overhead-piping safety pans.

1.2 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim assemblies as indicated shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.

B. Fabricate and install roof edge flashing and copings capable of resisting the following forces according to recommendations in ASCE 7-16 and FMG Loss Prevention Data Sheet 1-49:

1. Building Risk Category IV, Basic Wind Speed 170 mph, Exposure C, mean roof height 170 ft.

C. Thermal Movements: Provide sheet metal flashing and trim that allows for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F material surfaces.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each manufactured product and accessory.

B. Shop Drawings: Show fabrication and installation layouts of sheet metal flashing and trim, including plans, elevations, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled work. Include the following:

1. Identification of material, thickness, weight, and finish for each item and location in Project.
2. Details for forming sheet metal flashing and trim, including profiles, shapes, seams, and dimensions.
3. Details for joining, supporting, and securing sheet metal flashing and trim, including layout of fasteners, cleats, clips, and other attachments. Include pattern of seams.
4. Details of termination points and assemblies, including fixed points.
5. Details of expansion joints and expansion-joint covers, including showing direction of expansion and contraction.
6. Details of edge conditions, including eaves, ridges, valleys, rakes, crickets, and counter flashings as applicable.
7. Details of special conditions.
8. Details of connections to adjoining work.
9. Detail formed flashing and trim at a scale of not less than 3 inches per 12 inches.

C. Samples for Initial Selection: For each type of sheet metal flashing, trim, and accessory indicated with factory-applied color finishes involving color selection.

D. Qualification Data: For qualified fabricator.

E. Maintenance Data: For sheet metal flashing, trim, and accessories to include in maintenance manuals.

F. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.

B. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" unless more stringent requirements are specified or shown on Drawings.

C. Preinstallation Conference: Conduct conference at Project site.

1. Meet with COR, FAA’s insurer if applicable, Installer, and installers whose work interfaces with or affects sheet metal flashing and trim including installers of roofing materials, roof accessories, unit skylights, and roof-mounted equipment.
2. Review methods and procedures related to sheet metal flashing and trim.
3. Examine substrate conditions for compliance with requirements, including flatness and attachment to structural members.
4. Review special roof details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect sheet metal flashing.
5. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal flashing and trim materials away from uncured concrete and masonry.

B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to the extent necessary for the period of sheet metal flashing and trim installation.

1.6 WARRANTY

A. Special Warranty on Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

   a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SHEET METALS

A. General: Protect mechanical and other finishes on exposed surfaces from damage by applying a strippable, temporary protective film before shipping.

B. Aluminum Sheet: ASTM B 209, alloy as standard with manufacturer for finish required, with temper as required to suit forming operations and performance required.

1. Surface: Smooth, flat

2. Exposed Coil-Coated Finishes:

   a. Three-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

3. Color: As selected by Architect from manufacturer's full range.
4. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.

2.2 UNDERLAYMENT MATERIALS

A. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.

1. Thermal Stability: ASTM D 1970; stable after testing at 240 deg F.
2. Low-Temperature Flexibility: ASTM D 1970; passes after testing at minus 20 deg F.
3. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Carlisle Coatings & Waterproofing Inc.; CCW WIP 300HT.
b. Grace Construction Products, a unit of W. R. Grace & Co.; Ultra.
c. Henry Company; Blueskin PE200 HT.
d. Metal-Fab Manufacturing, LLC; MetShield.
e. Owens Corning; WeatherLock Metal High Temperature Underlayment.

B. Slip Sheet: Building paper, 3-lb/100 sq. ft. Minimum, rosin sized.

2.3 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.

B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.

1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.

a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating.
b. Blind Fasteners: High-strength aluminum or stainless steel rivets suitable for metal being fastened.
c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.

2. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
3. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.
4. Fasteners for Zinc-Tin Alloy-Coated Stainless-Steel Sheet: Series 300 stainless steel.

C. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.

D. Elastomeric Sealant: ASTM C 920, elastomeric polyurethane polymer sealant; low modulus; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

E. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.

F. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

G. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required for application.

2.4 MANUFACTURED SHEET METAL FLASHING AND TRIM

A. Reglets: Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counter flashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions with interlocking counter flashing on exterior face, of same metal as reglet.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Cheney Flashing Company.
   b. Fry Reglet Corporation.
   c. Heckmann Building Products Inc.
   d. Hickman, W. P. Company.
   e. Hohmann & Barnard, Inc.; STF Sawtooth Flashing.
   f. Keystone Flashing Company, Inc.
   g. National Sheet Metal Systems, Inc.
   h. Sandell Manufacturing Company, Inc.

3. Material: Aluminum, 0.024 inch thick.
4. Surface-Mounted Type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers and with channel for sealant at top edge.
5. Concrete Type: Provide temporary closure tape to keep reglet free of concrete materials, special fasteners for attaching reglet to concrete forms, and guides to ensure alignment of reglet section ends.
6. Accessories:

   a. Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counter flashing or where Drawings show reglet without metal counter flashing.
   b. Counter flashing Wind-Restraint Clips: Provide clips to be installed before counter flashing to prevent wind uplift of counter flashing lower edge.

7. Finish: Mill

2.5 FABRICATION, GENERAL

A. General: Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, geometry, metal thickness, and other characteristics of item indicated. Fabricate items at the shop to greatest extent possible.

1. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
2. Obtain field measurements for accurate fit before shop fabrication.
3. Form sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
4. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces exposed to view.

B. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet on slope and location lines as indicated and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

C. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

D. Sealed Joints: Form non-expansion but movable joints in metal to accommodate elastomeric sealant.

E. Expansion Provisions: Where lapped expansion provisions cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with butyl sealant concealed within joints.

F. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

G. Fabricate cleats and attachment devices of sizes as recommended by SMACNA's "Architectural Sheet Metal Manual" and by FMG Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.

H. Seams: Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.

I. Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.

J. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints where necessary for strength.

K. Do not use graphite pencils to mark metal surfaces.

L. Parapet Scuppers: Fabricate scuppers of dimensions required with closure flange trim to exterior, 4-inch- wide wall flanges to interior, and base extending 4 inches beyond cant or tapered strip into field of roof. Fasten gravel guard angles to base of scupper. Fabricate from the following materials:

1. Copper: 16 oz./sq. ft.

2.6 ROOF DRAINAGE SHEET METAL FABRICATIONS

A. Parapet Scuppers: Fabricate scuppers of dimensions required with closure flange trim to exterior, 4-inch- wide wall flanges to interior, and base extending 4 inches beyond cant or tapered strip into field of roof. Fasten gravel guard angles to base of scupper. Fabricate from the following materials:

1. Aluminum: 0.032 inch

2.7 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Copings: Fabricate in minimum 96-inch- long, but not exceeding 10-foot- long, sections. Fabricate joint plates of same thickness as copings. Furnish with continuous cleats to support edge of external leg and drill elongated holes for fasteners on interior leg. Miter corners, seal, and solder or weld watertight.

1. Coping Profile: SMACNA figure designation 3-4B
2. Joint Style: Butt, with 12-inch- wide, concealed backup plate.
3. Fabricate from the following materials:

a. Aluminum: 0.050 inch thick.

B. Roof and Roof to Wall Transition Roof to Roof Edge Flashing (Gravel Stop) Transition Roof to Roof Edge Flashing (Gravel Stop) and Fascia Cap Transition Expansion-Joint Cover: Fabricate from the following materials:

1. Aluminum: 0.050 inch thick.

C. Base Flashing: Fabricate from the following materials:

1. Aluminum: 0.040 inch thick.

D. Counter flashing: Fabricate from the following materials:

1. Aluminum: 0.032 inch thick.

E. Flashing Receivers: Fabricate from the following materials:

1. Aluminum: 0.032 inch thick.

2.8 WALL SHEET METAL FABRICATIONS

A. Opening Flashings in Frame Construction: Fabricate head, sill, jamb, and similar flashings to extend 4 inches beyond wall openings. Form head and sill flashing with 2-inch- high, end dams. Fabricate from the following materials:

1. Aluminum: 0.032 inch thick.

B. Wall Expansion-Joint Cover: Fabricate from the following materials:

1. Aluminum: 0.040 inch thick.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions and other conditions affecting performance of the Work.

1. Verify compliance with requirements for installation tolerances of substrates.
2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.

B. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 UNDERLAYMENT INSTALLATION

A. General: Install underlayment as indicated on Drawings.

B. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free. Apply primer if required by underlayment manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply in shingle fashion to shed water, with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps with roller. Cover underlayment within 14 days.

3.3 INSTALLATION, GENERAL

A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.

1. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.

2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
3. Space cleats not more than 12 inches apart. Anchor each cleat with two fasteners. Bend tabs over fasteners.
4. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.
5. Install sealant tape where indicated.
6. Torch cutting of sheet metal flashing and trim is not permitted.
7. Do not use graphite pencils to mark metal surfaces.

B. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by SMACNA.

1. Coat back side of uncoated aluminum sheet metal flashing and trim with bituminous coating where flashing and trim will contact wood, ferrous metal, or cementitious construction.
2. Underlayment: Where installing metal flashing directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet or install a course of polyethylene sheet.

C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently watertight, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with sealant concealed within joints.

D. Fastener Sizes: Use fasteners of sizes that will penetrate metal decking not less than recommended by fastener manufacturer to achieve maximum pull-out resistance

E. Seal joints as shown and as required for watertight construction.

1. Where sealant-filled joints are used, embed hooked flanges of joint members not less than 1 inch into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is moderate, between 40 and 70 deg F, set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F.
2. Prepare joints and apply sealants to comply with requirements in Section 07 92 00 "JOINT SEALANTS".

F. Rivets: Rivet joints in uncoated aluminum where indicated and where necessary for strength.

3.4 ROOF DRAINAGE SYSTEM INSTALLATION

A. General: Install sheet metal roof drainage items to produce complete roof drainage system according to SMACNA recommendations and as indicated. Coordinate installation of roof perimeter flashing with installation of roof drainage system.

B. Parapet Scuppers: Install scuppers where indicated through parapet. Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.

1. Anchor scupper closure trim flange to exterior wall and seal with elastomeric sealant to scupper.

C. Expansion-Joint Covers: Install expansion-joint covers at locations and of configuration indicated. Lap joints a minimum of 4 inches in direction of water flow.

3.5 ROOF FLASHING INSTALLATION

A. General: Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, set units true to line, and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

B. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in SMACNA's "Architectural Sheet Metal Manual" and as indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at staggered 3-inch centers.

C. Copings: Anchor to resist uplift and outward forces according to recommendations in SMACNA's "Architectural Sheet Metal Manual" and as indicated.

1. Interlock exterior bottom edge of coping with continuous cleat anchored to substrate at 12 inch centers.
2. Anchor interior leg of coping with washers and screw fasteners through slotted holes at 24-inch centers.

D. Counter flashing: Coordinate installation of counter flashing with installation of base flashing. Insert counter flashing in reglets or receivers and fit tightly to base flashing. Extend counter flashing 4 inches over base flashing. Lap counter flashing joints a minimum of 4 inches and bed with sealant. Secure in a waterproof manner by means of snap-in installation and sealant or lead wedges and sealant interlocking folded seam or blind rivets and sealant anchor and washer at 36-inch centers.

3.6 WALL FLASHING INSTALLATION

A. General: Install sheet metal wall flashing to intercept and exclude penetrating moisture according to SMACNA recommendations and as indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.

B. Reglets: Installation of reglets is specified in Section 03 30 00 "CAST-IN-PLACE CONCRETE”.

3.7 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet on slope and location lines as indicated and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

B. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

3.8 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder.

C. Clean off excess sealants.

D. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturers written installation instructions. On completion of installation, remove unused materials and clean finished surfaces. Maintain in a clean condition during construction.

E. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 62 00

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SECTION 07 71 00 - ROOF SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies Formed sheet metal work for drainage specialties including gutters and downspouts.

1.2 RELATED WORK

A. Manufactured flashing, copings, roof edge metal, and fasciae: Section 07 71 00 ROOF SPECIALTIES.

B. Membrane base flashings and stripping: Section 07 54 19 (PVC) ROOFING MEMBRANE

C. Flashing components of factory finished roofing and wall systems: Division 07

D. Joint Sealants: Section 07 92 00, JOINT SEALANTS

Sealant material and installation: Section 07 92 00, JOINT SEALANTS.

E. Rigid insulations for roofing: Section 07 21 00, THERMAL INSULATION

1.3 QUALITY CONTROL

A. All roof accessories shall be the products of manufacturers regularly engaged in producing the kinds of products specified.

B. Each accessory type shall be the same and be made by the same manufacturer.

C. Each accessory shall be completely assembled to the greatest extent possible before delivery to the site.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.

B. Samples: Representative sample panel of color Metal finishes less than 100 mm X 100 mm (four by four inches), except extrusions shall be a width not less than section to be used. Sample shall show coating with integral color and texture and shall include manufacturer's identifying label.

C. Shop Drawings: Each item specified showing design, details of construction, installation and fastenings.

D. Manufacturer's Literature and Data: Each item specified.

E. Certificates: Stating that aluminum has been given specified thickness of anodizing.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extended referenced. The publications are referenced in the text by the basic designation only.

B. American Society for Testing and Material (ASTM):

A653/A653M-10 .... Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) By the Hot-Dip Process

B209/209M-07 .... Aluminum and Aluminum Alloy-Sheet and Plate

B221/221M-08 .... Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes

C612-10 .... Mineral Fiber Block and Board Thermal Insulation

D1187-97(R2002) .... Asphalt-Base Emulsions for Use as Protective Coatings for Metal

C. American Architectural Manufacturers Association (AAMA):

2605-11................................ High Performance Organic Coatings on Architectural Extrusions and Panels.

PART 2 – PRODUCTS

2.1 HANGING GUTTERS

A. Fabricate gutters of not less than the following:

1. 0.032 thick aluminum.

B. Fabricate hanging gutters in sections not less than 2400 mm (8 feet) long, except at ends of runs where shorter lengths are required.

C. Building side of gutter shall be same height as exterior side//.

D. Gutter Bead: Stiffen outer edge of gutter by folding edge over approximately 19 mm (3/4 inch) toward roof and down approximately19 mm (3/4 inch) unless shown otherwise.

E. Gutter Spacers:

1. Fabricate of same material and thickness as gutter.
2. Fabricate 25 mm (one inch) wide strap and fasten to gutters not over 900 mm (36 inches) on center.
3. Turn back edge up 25 mm (one inch) and lap front edge over gutter bead.
4. Rivet and solder to gutter except rivet and seal to aluminum.

F. Outlet Tubes:

1. Form outlet tubes to connect gutters to conductors of same metal and thickness as gutters extend into the conductor 75 mm (3 inch). Flange upper end of outlet tube 13 mm (1/2 inch).
2. Lock and seal longitudinal seam.
3. Seal aluminum tube to gutter and rivet to gutter.
4. Fabricate basket strainers of same material as gutters.

G. Gutter Brackets:

1. Fabricate of same metal as gutter. Use the following:

   a. 6 by 25 mm (1/4 by 1 inch) aluminum.

2. Fabricate to gutter profile.
3. Drill two 5 mm (3/16 inch) diameter holes in anchor leg for countersunk flat head screws.

2.12 CONDUCTORS (DOWNSPOUTS)

A. Fabricate conductors of same metal and thickness as gutters in sections approximately 3000 mm (10 feet) long with 19 mm (3/4 inch) wide flat locked seams.

B. Fabricate elbows by mitering, riveting, and sealing. Lap upper section to the inside of the lower piece.

C. Fabricate conductor brackets or hangers of same material as conductor, 2 mm (1/16 inch) thick by 25 mm (one inch) minimum width. Form to support conductors 25 mm (one inch) from wall surface in accordance with Architectural Sheet Metal Manual Plate 34, Design C for rectangular shapes and E for round shapes.

D. Conductor Heads:

1. Fabricate of same material as conductor.
2. Fabricate conductor heads to not less than 250 mm (10 inch) wide by 200 mm (8 inch) deep by 200 mm (8 inches) from front to back.
3. Form front and side edges channel shape not less than 13 mm (1/2 inch) wide flanges with edge hemmed.
4. Slope bottom to sleeve to conductor or downspout at not less than 60 degree angle.
5. Extend wall edge not less than 25 mm (one inch) above front edge.
6. Solder joints for water tight assembly.

7. Fabricate outlet tube or sleeve at bottom not less than 50 mm (2 inches) long to insert into conductor.

2.13 SPLASHPANS

A. Fabricate splashpans from the following unless noted otherwise:

1. 1.25 mm (0.050 inch) thick aluminum.

B. Fabricate in accordance with Architectural Sheet Metal Manual Plate 35 with not less than two ribs as shown in alternate section.

END OF SECTION 07 71 00

SECTION 07 72 00 - ROOF ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Roof curbs
2. Equipment supports

1.2 SUBMITTALS

A. Product Data: For each type of roof accessory indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: Show fabrication and installation details for roof accessories. Show layouts of roof accessories including plans and elevations. Indicate dimensions, weights, loadings, required clearances, method of field assembly, and components. Include plans, elevations, sections, details, and attachments to other work.

C. Coordination Drawings: Roof plans, drawn to scale, and coordinating penetrations and roof-mounted items. Show the following:

1. Size and location of roof accessories specified in this Section.
2. Method of attaching roof accessories to roof or building structure.
3. Other roof-mounted items including mechanical and electrical equipment, ductwork, piping, and conduit.

D. Samples: For each type of exposed factory-appliedfinish required and for each type of roof accessory indicated, prepared on Samples of size to adequately show color.

E. Warranty: Special warranty specified in this Section.

1.3 QUALITY ASSURANCE

A. Sheet Metal Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" details for fabrication of units, including flanges and cap flashing to coordinate with type of roofing indicated.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Pack, handle, and ship roof accessories properly labeled in heavy-duty packaging to prevent damage.

1.5 PROJECT CONDITIONS

A. Field Measurements: Verify required openings for each type of roof accessory by field measurements before fabrication and indicate measurements on Shop Drawings.

1.6 COORDINATION

A. Coordinate layout and installation of roof accessories with roofing membrane and base flashing and interfacing and adjoining construction to provide a leakproof, weathertight, secure, and noncorrosive installation.

1. With Architect's approval, adjust location of roof accessories that would interrupt roof drainage routes.

1.7 WARRANTY

A. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace roof accessories that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers listed in other Part 2 articles.

2.2 METAL MATERIALS

A. Galvanized Steel Sheet: ASTM A 653/A 653M, G90 coated.

B. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, AZ50 coated.

C. Aluminum Sheet: ASTM B 209, alloy and temper recommended by manufacturer for type of use and mill finish. Coil-coat finish as follows:

1. High-Performance Organic Finish (2-Coat Fluoropolymer): AA-C12C40R1x (Chemical Finish: Cleaned with inhibited chemicals; Chemical Finish: Conversion coating; Organic Coating: Manufacturer's standard 2-coat, thermocured system consisting of

specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with AAMA 2604 AAMA 2605 and with coating and resin manufacturer's written instructions.

a. Color and Gloss: As indicated by manufacturer's designations Match Architect's sample as selected by Owner from manufacturer's full range.

D. Stainless-Steel Shapes or Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304 or Type 316, No. 2D finish.

E. Steel Shapes: ASTM A 36/A 36M, hot-dip galvanized to comply with ASTM A 123/A 123M, unless otherwise indicated.

F. Steel Tube: ASTM A 500, round tube, baked-enamel finished.

G. Galvanized Steel Tube: ASTM A 500, round tube, hot-dip galvanized to comply with ASTM A 123/A 123M.

H. Galvanized Steel Pipe: ASTM A 53/A 53M.

2.3 MISCELLANEOUS MATERIALS

A. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 1, 1 inch thick.

B. Glass-Fiber Board Insulation: ASTM C 726, 1 inch thick.

C. Polyisocyanurate Board Insulation: ASTM C 1289, 1 inch thick.

D. Wood Nailers: Softwood lumber, pressure treated with waterborne preservatives for aboveground use, complying with AWPA C2; not less than 1-1/2 inches thick.

E. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

F. Fasteners: Same metal as metals being fastened, or nonmagnetic stainless steel or other noncorrosive metal as recommended by roof accessory manufacturer. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners.

G. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, or PVC; or flat design of foam rubber, sponge neoprene, or cork.

H. Elastomeric Sealant: ASTM C 920, polyurethane polysulfide silicone sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

I. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, and heavy bodied for hooked-type expansion joints with limited movement.

J. Roofing Cement: ASTM D 4586, nonasbestos, fibrated asphalt cement designed for trowel application or other adhesive compatible with roofing system.

2.4 ROOF CURBS

A. Roof Curbs: Provide metal roof curbs, internally reinforced and capable of supporting superimposed live and dead loads, including equipment loads and other construction to be supported on roof curbs. Fabricate with welded or sealed mechanical corner joints, with and integral formed mounting flange at perimeter bottom. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

1. Available Manufacturers:

   a. Colony Custom Curbs.
   b. Commodity Products Company, Inc.
   c. Conn-Fab Sales, Inc.
   d. Curbs Plus Inc.
   e. Custom Curb, Inc.
   f. Greenheck.
   g. LM Curbs.
   h. Loren Cook Company.
   i. Metallic Products Corporation.
   j. Pate Company (The).
   k. Roof Products & Systems Corporation.
   l. Roof Products, Inc.
   m. Thaler Metal Industries Ltd.
   n. ThyCurb; Div. of Thybar Corporation.
   o. Uni-Curb, Inc.
   p. Vent Products Company, Inc.

2. Material: Aluminum sheet, 0.090 inch thick.

   a. Finish: High-performance organic coating.

3. Liner: Same material as curb, of manufacturer's standard thickness and finish.
4. Factory install wood nailers at tops of curbs.
5. On ribbed or fluted metal roofs, form flange at perimeter bottom to conform to roof profile.
6. Factory insulate curbs with 1-1/2-inch- thick, cellulosic -fiber board insulation.
7. Curb height may be determined by adding thickness of roof insulation and minimum base flashing height recommended by roofing membrane manufacturer. Fabricate units to minimum height of 12 inches , unless otherwise indicated.
8. Sloping Roofs: Where slope of roof deck exceeds 1:48, fabricate curb units with water diverter or cricket and with height tapered to match slope to level tops of units.

2.5 EQUIPMENT SUPPORTS

A. Equipment Supports: Provide metal equipment supports, internally reinforced and capable of supporting superimposed live and dead loads, including equipment loads and other construction to be supported. Fabricate with welded or sealed mechanical corner joints, with and integral formed mounting flange at perimeter bottom. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

1. Available Manufacturers:

a. Colony Custom Curbs.
b. Commodity Products Company, Inc.
c. Conn-Fab Sales, Inc.
d. Curbs Plus Inc.
e. Custom Curb, Inc.
f. LM Curbs.
g. Loren Cook Company.
h. Metallic Products Corporation.
i. Pate Company (The).
j. Roof Products & Systems Corporation.
k. Roof Products, Inc.
l. Thaler Metal Industries Ltd.
m. ThyCurb; Div. of Thybar Corporation.
n. Uni-Curb, Inc.
o. Vent Products Company, Inc.

2. Material: Aluminum sheet, 0.090 inch thick.

a. Finish: High-performance organic coating.

3. Factory-install continuous wood nailers 3-1/2 inches wide at tops of equipment supports.
4. Metal Counterflashing: Manufacturer's standard removable counterflashing, fabricated of same metal and finish as equipment support.
5. On ribbed or fluted metal roofs, form flange at perimeter bottom to conform to roof profile.
6. Fabricate units to minimum height of 12 inches , unless otherwise indicated.
7. Sloping Roofs: Where slope of roof deck exceeds 1:48, fabricate curb units with water diverter or cricket and with height tapered to match slope to level tops of units.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of work.

1. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored and is ready to receive roof accessories.
2. Verify dimensions of roof openings for roof accessories.

3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install roof accessories according to manufacturer's written instructions. Anchor roof accessories securely in place and capable of resisting forces specified. Use fasteners, separators, sealants, and other miscellaneous items as required for completing roof accessory installation. Install roof accessories to resist exposure to weather without failing, rattling, leaking, and fastener disengagement.

B. Install roof accessories to fit substrates and to result in watertight performance.

C. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.

1. Coat concealed side of uncoated aluminum roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
2. Underlayment: Where installing exposed-to-view components of roof accessories directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet, or install a course of polyethylene underlayment.
3. Bed flanges in thick coat of asphalt roofing cement where required by roof accessory manufacturers for waterproof performance.

D. Install roof accessories level, plumb, true to line and elevation, and without warping, jogs in alignment, excessive oil canning, buckling, or tool marks.

E. Roof Curb Installation:

1. Set roof curb so top surface of roof curb is level.

F. Equipment Support Installation:

1. Set equipment support so top surface of equipment support is level.

G. Seal joints with elastomeric sealant as required by manufacturer of roof accessories.

3.3 TOUCH UP

A. Touch up factory-primed surfaces with compatible primer ready for field painting in accordance with Section 09 91 00 “PAINTING”.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

3.4 CLEANING

A. Clean exposed surfaces according to manufacturer's written instructions.

END OF SECTION 07 72 00

SECTION 07 72 33 – ROOF HATCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Roof Hatches.
      a. Personnel Series metal, single door hatches used by personnel.
   2. Accessory Products for Roof Hatches
      a. Safety Railings for all roof hatches

B. Related Requirements:
   1. Division 055000 “Metal Fabrications” for metal vertical ladders, ships’ ladders and stairs for access to roof hatches

1.2 COORDINATION

A. Coordinate layout and installation of roof accessories with roofing membrane and base flashing and interfacing to provide a leak proof, watertight, secure and noncorrosive installation.

B. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

1.3 ACTION SUBMITTALS

A. Shop Drawings:
   1. Indicate configuration and dimension of components, adjacent construction, required clearances and tolerances, and other affected Work.
      a. Hatch Units: Show types, elevations, thickness of metals, and full size profiles.
      b. Hardware: Show materials, finishes, locations of fasteners, types of fasteners, locations and types of operating hardware, and details of installation.
      c. General: Show connections of units and hardware to other Work. Include schedules showing location of each type and size of unit.

B. Product Data: Manufacturer’s technical data for each type of hatch assembly, including setting drawings, templates, finish requirements, and details of anchorage devices.
   1. Include complete schedule, types, locations, construction details, finishes, latching or locking provisions, and other pertinent data.

1.4 CLOSEOUT SUBMITTALS

   1. Installation, Operating & Maintenance manuals

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. OSHA 29 CFR 1910.23 Guarding floor and wall openings and holes
   2. OSHA 29 CFR 1926.502 Fall protection systems criteria
   3. International Building Code (IBC) Section 1013.6 Roof Access
   4. International Building Code (IBC) Section 1009.11 Means of Egress, Stairways, Stairway to Roof

1.6 WARRANTY

A. Provide manufacturer's standard 5 year warranty. Roof hatches shall be free from manufacturing defects in materials and fabrication for a period of 5 years from the date of shipment. Should a product fail to function in normal use within this period, manufacturer shall furnish a replacement or new part at Nystrom's discretion.

PART 2 - PRODUCTS

2.1 MANUFACTURER

1. Nystrom
   9300 73rd Ave N
   Minneapolis, MN 55428
   Toll Free Hotline: 800-547-2635
   Direct Phone: 763-488-9200
   www.nystrom.com

2.2 PERSONNEL ROOF HATCH

A. Acceptable Manufacturers: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal:
   1. Nystrom, Model G3054

B. Type and Size: Personnel Single-leaf metal lid, G3054, 30 by 54 inches

   1. Loads: Cover stiffened to withstand a live load of 40-lb/sq. ft. with a maximum deflection of 1/150 of the span and 20-lb/sq. ft. internal uplift load.
   2. Hatch Material
      a. Cover: 11 GAGE ALUMINUM cover with 1 inch rigid insulation covered by 11 GAGE ALUMINUM cover liner.
      b. Curb: Use existing curb, modify as necessary to accommodate new roof hatch.
      c. Finish: MILL FINISHED ALUMINUM
      d. Color: ANSI 70 Gray
      e. Insulation: 1 inch (25mm) Polyisocyanurate R-6 (5.6 LTTR) in Curb and 1 inch (25mm) polystyrene in Cover
      f. Hardware: Zinc plated steel
         1) Hinge Assembly: Pintle hinge with stainless steel hinge pin
         2) Spring: Gas spring with integrated damper
         3) Hold open device: Automatic zinc plated steel hold open arm with red vinyl grip handle.
         4) Latch: Zinc plated steel spring type slam latch with inside and outside operating turn handles and padlock hasp provisions.
         5) Pull handle: Interior pull down handle, powder coated safety yellow
         6) Gasket: Extruded EPDM adhesive back seal, continuous around cover

2.3 ACCESSORY PRODUCTS

A. Safety Railing System: Roof-hatch manufacturer's standard system including rails, clamps, fasteners, safety barrier at railing opening, and accessories required for a complete installation; attached to roof hatch and complying with 29 CFR 1910.23 requirements and authorities having jurisdiction.
   1. Acceptable Manufacturers: Subject to compliance with requirements of the Contract Documents, acceptable manufacturers are as follows or approved equal: basis of design, Nystrom model: SRC
   2. Height: Height: 42 inches above finished roof deck.
   3. Rails:
      a. Material: Galvanized-steel pipe, 1-1/4 inch, (1.66 inch outside diameter) schedule 40 pipe
      b. Fittings: Cast aluminum alloy with set screw hold
      c. Mounting brackets: 3/16 inch (4.75 mm) steel, zinc plated with nut backing plate
      d. Exit: Self closing gate, Galvanized steel 1 ¼ inch (32 mm) tubular steel self closing with coil spring.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine site conditions under which work of this Section will be performed.
   1. Identify conditions detrimental to providing proper quality and timely completions of work.
   2. Do not proceed with installation until detrimental conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's recommendations.

B. Securely anchor roof accessories in compliance with manufacturer's instructions.

C. Set units plumb, level, and true to line without warp or rack.

D. Incompatible Materials: Apply protective coating to separate aluminum from incompatible materials.

3.3 ADJUSTING

A. Adjust movable parts for smooth operation.

B. Operational Units: Test-operate units with operable components. Clean and lubricate joints and hardware. Adjust for proper operation.

3.4 CLEANING

A. Clean exposed surfaces per manufacturer's written instructions. Touch up damaged metal coatings.

END OF SECTION 07 72 33

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SECTION 07 84 00 FIRESTOPPING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. The Contractor must furnish all labor, materials, equipment and incidentals necessary to install firestopping in locations indicated on the drawings and specified herein. Firestopping must be provided for all through-penetrations of fire-resistance rated assemblies. Fire-resistant joint systems must be provided at construction joints and gaps in fire-resistance rated assemblies. The contractor is responsible to determine the location of all fire-resistance rated assemblies that require firestopping and fire-resistant joint assemblies.

B. Firestopping consists of furnishing and installing tested and classified/approved firestop systems, combination of materials, or devices to form an effective barrier against the spread of flame, smoke and gases, and maintain the integrity of fire-resistance rated walls, barriers, partitions, floors, and floor/ceiling assemblies, including through-penetrations and construction joints and gaps. Through-penetrations include the annular space around pipes, tubes, conduit, wires, cables, vents and other penetrating items. Construction joints include those used to accommodate expansion, contraction, wind, or seismic movement; firestopping material must not interfere with the required movement of the joint. Gaps requiring firestopping include gaps between the curtain wall and the floor slab and between the top of the fire-rated walls and the roof or floor deck above.

1.2 REFERENCES –

INTERNATIONAL CODE COUNCIL (ICC)

IBC-2018	International Building Code
IFC-2018	International Fire Code

FM GLOBAL (FMG)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approval-guide.com/CC_host/pages/public/custom/FM/login.cfm

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101-2012	Life Safety Code

UNDERWRITERS LABORATORIES INC. (ULI)

UL Fire Resistance	Fire Resistance Directory

1.3 DEFINITIONS

A. Construction Gap: An open joint between adjacent assemblies; may be a moving joint or static opening, without penetrating items.

B. Fire-resistance rated: Having the ability to withstand the effects of a design fire for a specified time period, as determined by qualified testing.

C. Fire-resistance rated assembly: A floor, wall, or other partition able to withstand a design fire and hose stream test without failure.

D. Fire resistance rating: The time, in hours, for which the rated assembly can withstand the effects of a design fire without burn-through or structural failure.

E. Fire-resistant joint system: Joints installed in or between fire-resistance rated walls, floor or floor/ ceiling assemblies and roofs or roof/ceiling assemblies. Includes joints at Exterior curtain wall/floor intersections.

F. Firestop: A means of sealing openings in fire-resistance rated assemblies to preserve or restore the fire resistance rating.

G. Firestop system: Specific firestop material or materials, which when installed in openings in a specific rated assembly, achieve the performance required.

H. Listing: The current, published listing of a system in a qualified listing agency's directory.

I. Listing Agency: Independent testing agency that has conducted tests and classified firestop systems for particular applications, which conducts routine in-plant follow-up inspections, and which lists tested systems in a published directory.

J. Penetrating Item: A pipe, duct, conduit, cable tray, cable, or other element passing through an opening in a fire-resistance rated assembly. This is also called the penetrant.

K. Through-Penetration: A hole through a rated assembly made to accommodate the passage of a penetrating item or an empty hole made for another purpose and not repairable using the original materials of construction.

1.4 PERFORMANCE REQUIREMENTS

A. General: For penetrations through fire-resistance rated construction, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire resistance rating of construction penetrated.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per ASTM E 814:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire resistance rating of constructions penetrated.

2. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:

   a. Penetrations located outside wall cavities.
   b. Penetrations located outside fire-resistance rated shaft enclosures.

C. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.
2. For floor penetrations with annular spaces exceeding 4 inches (100 mm) in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved, either by installing floor plates or by other means.
3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

1.5 QUALITY ASSURANCE

A. Workmanship

1. Installation must conform to requirements of qualified designs or manufacturer approved modifications, as supported by engineering reports.

B. Installer qualifications

1. The Contractor must engage a single experienced installer who is FM Global approved in accordance with FM Standard 4991, OR certified, licensed, or otherwise qualified by the fires topping manufacturer as having the necessary staff, training, and a minimum of 3 years’ experience in the installation of the manufacturer’s products. A manufacturer’s willingness to sell its fire stopping products to the Contractor or to an installer engaged by the Contractor does not in itself confer qualification on the buyer. The Installer must have been trained by a direct representative of the manufacturer (not distributor or agent) in the proper selection and installation procedures.

2. Installer must have successfully completed, within the last 3 years, at least three firestop projects similar in type and size to this project and must be certified by the manufacturer for the installation of the firestop systems to be used on this project. Installer must provide descriptions of past projects, along with references and contact information.

C. Installation Responsibility: Assign installation of through-penetration firestop systems and fire-resistive joint systems in Project to a single qualified installer.

D. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, through one source from a single manufacturer.

E. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in Part 1 "Performance Requirements" Article:

1. Firestopping tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL, or another agency performing testing and follow-up inspection services for firestop systems acceptable to the FAA.

2. Through-penetration firestop systems are identical to those tested per testing standard referenced in "Part 1 Performance Requirements" Article. Provide rated systems complying with the following requirements:

a. Through-penetration firestop system products bear classification marking of qualified testing and inspecting agency.
b. Through-penetration firestop systems correspond to those indicated by reference to through-penetration firestop system designations listed by the following:

1) UL in its "Fire Resistance Directory."

1.6 PRE-CONSTRUCTION CONFERENCE

A. Upon direction of the FAA, meet at the Project site with the Contracting Officer Representative (COR), installer, installer of each component of associated work, Architect/Engineer, joint/through-penetration firestop system manufacturer’s representative, and other representatives directly concerned with performance of the work, including any governing authorities.

B. Review foreseeable methods and procedures related to fire-resistive joint systems and through-penetration firestop systems work, including but not limited to the following:

1. Inspect and discuss condition of substrate, joints, and penetrations.
2. Review of locations requiring firestopping and fire-resistive joints.
3. Review fire-resistive joint and through-penetration firestop system requirements (drawings, specifications, manufacturer’s written instructions).
4. Review required submittals, both completed and yet to be completed.

5. Review and finalize construction schedule related to work and verify availability of materials, installer's personnel, equipment, and facilities needed to make progress and avoid delays.
6. Review required inspection, testing, certifying, and material usage accounting procedures.

C. Contractor must record discussions of conference including decisions and agreements (or disagreements) reached, and furnish copy of record to each party attending. If substantial disagreements exist at the conclusion of the conference, determine how the disagreements will be resolved and set a date for a reconvening conference.

1.7 SUBMITTALS

A. General

1. Prior to installation, but within 30 calendar days after contract award, submit to the COR 6 complete sets containing each item listed below.
2. The COR will recommend "accept/reject" or take other appropriate action on the submittals including shop drawings, samples, documentation and as-built drawings. This review is to verify conformance to project specifications and design concepts expressed in the contract documents. Review of such submittals is not conducted for the purpose of determining the accuracy and completeness of other details (i.e., dimensions) or for substantiating installation or performance of the products used by the Contractor, all of which remain the Contractor's responsibility to the extent required by the contract documents. Review does not constitute approval of safety precautions of construction, means, methods, techniques, sequences of procedures, or approval of a specific assembly of which the item is a part.
3. If submittals are found not to conform to the requirements of these specifications, the Contractor is required to resubmit with modifications.
4. Acceptance of the submittals by the COR, does not, in any case, relieve the Contractor from his responsibility to meet the requirements of this specification.

B. Data Sheets

1. Submit manufacturer's product literature for each type of firestop device and system to be installed. All literature must include the UL Classification mark or other qualified Listing Agency's approval. Literature must indicate product characteristics, typical uses, performance and limitation criteria, test data, and storage requirements. Include a copy of the firestop system listing from the Listing Agency's published directory. Where "engineered systems" are used, provide a copy of the manufacturer's written documentation on the engineered system. Provide literature for all products used in the system including packing, firesafing, caulk, and other materials.

C. Material Safety Data Sheets (MSDS)

1. Submit MSDS information for each firestop product.

D. Shop Drawings

1. Show typical installation details for methods of installation. Clearly indicate on the drawings where each type of firestop device and system will be used. Submit manufacturer's installation procedures for each product used in every system. For through-penetration firestop systems, clearly indicate the penetrating items (including quantity, sizes and groupings) and the fire-resistance rated assembly being penetrated.

E. Installer Certification

1. Submit manufacturer's certification of the installer for said manufacturer's firestop products.
2. Submit descriptions and contact information for at least three (3) previous firestop projects, similar in size and type to this project.

F. Final Documentation

1. Provide final as-built drawings clearly depicting the installed location and type of all firestop systems under this project.
2. Include all listing sheets and any engineering judgment documents for systems installed with the final documentation package.

1.8 REGULATORY REQUIREMENTS

A. Firestop systems must be installed in all openings and around all penetrating elements or devices or construction joints/gaps as required by these Contract Documents and as shown on the drawings.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not store, use or install firestopping under environmental conditions outside manufacturer's absolute limits. Provide proper ventilation in installation areas and all areas affected by installation. Comply with recommended procedures, precautions, or remedies described in the MSDS as applicable. Dispose of excess materials as required in the MSDS and manufacturer's instructions. Excess materials must be disposed of off-site by the Contractor.

B. Ventilate through-penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.10 DELIVERY AND STORAGE

A. Deliver materials to the site in original unopened containers or bags bearing the name of manufacturer, product name, type, grade and UL listing (or other acceptable approval or listing mark) where applicable. Coordinate delivery of materials with scheduled installation date to allow minimum storage time at job site.

B. The Contractor is responsible for the storage of the products. The Contractor must provide storage facilities as necessary to store and protect the firestop materials in a manner and location as approved by the COR.

C. Storage of products must be off the ground and comply with manufacturer's requirements for each product. Storage must be in an area protected from weather, moisture, and freezing. Coordinate the location of storage facilities with COR.

D. Comply with recommended procedures, precautions or remedies described in the MSDS as applicable. All firestop materials must be installed prior to expiration of shelf life.

1.11 COORDINATION

A. The specified work must be coordinated with other trades. Firestopping materials, at penetrations of pipes and ducts, must be applied prior to insulating, unless insulation meets requirements specified for firestopping. Firestopping materials at building joints and construction gaps must be applied prior to completion of enclosing walls or assemblies.

B. Firestop assemblies to be concealed by enclosing walls or assemblies must be inspected by the COR prior to enclosure. The Contractor must notify COR a minimum of 48 hours in advance of concealing firestop assemblies.

C. Notify FAA's inspecting agency at least seven days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by the FAA's inspecting agency.

1.12 EXTRA MATERIALS

A. Provide the following extra materials, in their original, unopened containers, and field installation instructions to the COR at the completion of the project.

1. Firestop Sealant or Putty: One cartridge of sealant and five sticks of putty of each type used.
2. Cementitious Firestop Mortars: Five pounds of dry material of each type used.
3. Firestop Collars/Intumescent Wrap Strips: One collar and five wrap strips of each type used.
4. Non-combustible Insulation: One standard roll.
5. Pillows or Bricks: Five of each type used.
6. Intumescent Sheets: One sheet of each type used.
7. Fire-Rated Pathways: One of each size and type used.

1.13 TRAINING

A. Timing: Conduct 2 training sessions of 2 hours each to familiarize FAA personnel with the features and installation of the new firestop systems. Training sessions must be scheduled with the FAA at a time mutually agreeable to the Contractor and the FAA.

B. Agenda: The Contractor must submit a proposed training agenda for the FAA's review. The final, approved training agenda must be submitted prior to the CAI. Training must include familiarization and repair of all firestop systems installed.

C. Documentation of Training: The Contractor is responsible for videotaping a presentation of the contents of the FAA training sessions taped outside the actual FAA training sessions with specific instructions on the installed system features, operation, and maintenance. Provide 2 copies of the draft training video session to the FAA for review and comments within 5 days prior to the first training session. Incorporate FAA comments. Two copies of the final video training sessions must be provided to the FAA within 14 calendar days of completion of the final training session.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each that are produced by one of the following manufacturers:

1. A/D Fire Protection Systems Inc.
2. Grace, W. R. & Co. - Conn.
3. Hilti, Inc.
4. Johns Manville.
5. Nelson Firestop Products.
6. NUCO Inc.
7. RectorSeal Corporation (The).
8. Specified Technologies Inc.
9. 3M; Fire Protection Products Division.
10. Tremco; Sealant/Weatherproofing Division.
11. USG Corporation.

2.2 MATERIALS

A. General Requirements - Firestop materials must be listed for use in firestopping systems to achieve the specified F, T and L ratings in accordance with ASTM E814 (UL 1479). The “F” rating must be at least equal to fire rating of fire-resistance rated wall, floor or partition in which penetrated openings are to be protected. Firestop systems must also have a corresponding “T” and “L” ratings where required by the referenced codes. Materials must be non-asbestos and non-toxic to human beings during installation and fire conditions. Material must have a flamespread rating of 25 or less, and a smoke development rating of 50 or less when tested in accordance with UL 723 or UL listed and accepted.

B. Each firestop material used must be suitable and listed for firestopping the penetrations (steel, glass, plastic and insulated pipe, conduit, flexible cable, bus duct, cable tray) for which it is used.

C. Firestop materials must not be used in annular spaces greater than annular space tested per its listing. Do not use any firestop material which is chemically incompatible with plastic covered cables, PVC pipe, drop tubes, etc.

D. To the maximum extent practical, all firestop products and systems must be of a single manufacturer. The use of multiple manufacturers' systems must be approved by the COR prior to submittal.

2.3 APPLICATION

A. Products selected must listed for the specific application and must be selected based upon environmental conditions such as the penetrant, partition type, partition thickness, penetration configuration, fire resistance rating, etc.

2.4 MIXING

A. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions where the firestop system is to be installed and notify the COR of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until satisfactory conditions have been achieved in a manner acceptable to the COR. Verify that all penetrating elements and supporting devices are safe and suitable for installation of firestop products.

3.2 GENERAL CONSIDERATIONS

A. Firestop systems do not re-establish the structural integrity of load bearing partitions. Consult structural engineer prior to drilling or coring operations in any load bearing assembly. Firestop systems are not intended to support live loads and traffic. Curbs or steel plates may be required to restrict or accommodate potential traffic. Contractor must notify the COR if he has reason to believe these limitations may be violated.

3.3 PREPARATION

A. Conform to manufacturer's detailed recommendations for surface preparation. Surface to receive firestopping must be free of dirt, dust, grease, oil, form release agents, rust or other matter. Voids and cracks in substrate must be filled and unnecessary projections removed prior to installation of firestopping. All penetrating items must be permanently installed prior to firestop installation. Substrate must be frost-free and, when applicable, dry. Provide covering for protection of adjacent areas in accordance with good work practices.

B. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with firestop system manufacturer's written instructions and with the following requirements:

1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form-release agents from concrete.

C. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

D. Masking Tape: Use masking tape to prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

3.4 INSTALLATION

A. General

1. Firestop systems must be installed in accordance with its listing. The types, amounts, methods, manufacturers, etc. of every system must be in strict accordance with its listing. Substitutions of like materials by the same or other manufacturers are strictly prohibited.
2. Installation must be performed in strict accordance with manufacturer's detailed installation recommendations, fire test reports, fire resistance requirements, and acceptable sample installations.
3. Ensure effective seal against flame, smoke, heat, and hot gases. Do not install water-based products at building exterior. Firestop systems and materials must not require special tools for installation and must not emit hazardous, combustible, or irritating fumes during installation, curing or use.
4. Follow safety procedures recommended by the manufacturer's design requirements pertaining to cable separation to obtain a smooth, professional finish.
5. Firestopping material must completely fill void spaces regardless of geometric configuration, subject to tolerance established by the manufacturer. Firestop systems for filling floor voids 4 inches or more in any direction must be capable of supporting the same

load as the floor is designed to support or must be protected by a permanent barrier to prevent loading or traffic in the firestopped area.

6. Tested and classified firestop systems must be provided in the following locations, except in floor slabs on grade:

    a. Penetrations of duct, conduit, tubing, cable and pipe through fire-resistance rated walls, partitions, and ceiling-floor assemblies.
    b. Penetrations of vertical shafts such as electrical chases and utility chases.
    c. Joints at the intersection of floor slabs and curtain walls, including inside of hollow curtain walls at the floor slab.
    d. Joints at perimeter of fire-resistance rated walls and partitions, such as between the top of the walls and the bottom of roof decks.
    e. Other locations where required to maintain fire resistance rating of the construction.

B. Damming

1. Install dams when required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Combustible damming material must be removed after appropriate curing. Non-combustible damming materials may be left as a permanent component of the firestop system if consistent with the listing.

C. Insulated Pipes and Ducts

1. Thermal insulation must be cut and removed where pipes or ducts pass through firestopping, unless insulation meets requirements specified for firestopping. Thermal insulation must be replaced with a material having equal thermal insulating and firestopping characteristics.

D. Data and Communication Cable Trays

1. Cables penetrating through fire-rated floors or walls (where not already enclosed in conduit or raceway) must utilize fire-rated pathway devices capable of providing an F rating equal to the rating of the barrier in which the device is installed. The installed device (in normal use) must require no maintenance and must accommodate future cable changes without mechanical adjustment and/or removal or replacement of protective materials.

2. If possible, cable trays must terminate prior to passing through walls.

E. Fire dampers

1. Follow manufacturer recommended guidelines for provided fire stopping products around fire damper penetrations.

3.5 REPAIRS AND MODIFICATIONS

A. Identify damaged or re-entered seals requiring repair or modification and remove loose or damaged materials. If penetrating elements are to be added, remove enough material to insert new elements, being careful not to cause damage to the balance of the seal. Insure that surfaces to be sealed are clean and dry. Use only materials approved by manufacturer as suitable for repair of original seal.

3.6 SYSTEM IDENTIFICATION

A. Identify firestop systems with pressure sensitive, self-adhesive vinyl labels applied to both sides of the assembly, readily visible, depicting the following information:

1. The words "Warning - Through-Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage".
2. Installing Contractor's name, address and phone number.
3. System designation of applicable testing and inspection agency.
4. Date of installation.
5. Firestop system manufacturer's name.

3.7 CLEAN-UP

A. Clean surfaces adjacent to sealed joints of excess firestopping materials as work progresses, using solvent or cleaning agents recommended in writing by the firestop manufacturer. Remove equipment, materials, and debris, leaving area in a clean, undamaged condition.

3.8 FINAL INSPECTION

A. The COR must perform inspections to verify compliance with requirements. The Contractor must correct unacceptable work and provide further inspection to verify compliance with requirements. Examine penetration seals for proper installation, adhesion and curing as may be appropriate for the respective seal materials. Keep areas of work accessible. Document completion and inspection as required.

B. Contractor must make arrangements with the COR for final inspection. Contractor must provide at least fifteen calendar days written notice for all tests or as otherwise specified herein. Contractor must provide written certification, 14 calendar days prior to the final inspection, that the firestop systems have been installed as follows:

1. All penetrations indicated on the design drawings and as indicated by the COR have been sealed.
2. Spare systems for future use have been provided in accordance with this specification.

3. All penetrations have been sealed with an appropriate, correctly installed, classified firestop system in accordance with its listing and the manufacturer's installation instructions. The contractor must provide a copy of the UL Classification for the types of systems utilized as well as the locations each system was installed.
4. Component substitutions, as discussed in this specification, have not been made.
5. Firestop system identification tags have been installed.

C. If after being advised by the Contractor that the work is completed and ready for the inspection, the work has not been completed or the final inspection is unsatisfactory, the Contractor must be responsible for FAA's extra expenses including labor for all inspection and witnessing the re-test of the work. Such extra fees must be deducted from the payments made by FAA to the Contractor.

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SECTION 07 84 13 - PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes through-penetration firestop systems for penetrations through fire-resistance-rated constructions, including both empty openings and openings containing penetrating items.

1.2 PERFORMANCE REQUIREMENTS

A. General: For penetrations through fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
2. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:

a. Penetrations located outside wall cavities.
b. Penetrations located outside fire-resistance-rated shaft enclosures.

3. L-Rated Systems: Provide rough-penetration firestop systems with L-ratings of not more than 3.0 cfm/sq. ft at both ambient temperatures and 400 deg F.

C. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.
2. For floor penetrations with annular spaces exceeding 4 inches in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved, either by installing floor plates or by other means.
3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.

4. For penetrations involving cables and cable trays, provide a through penetration firestop system that permit the addition or removal of cables without damaging the firestop system. Provide Specified Technologies Inc, EZ-PATH, Hilti Firestop Sleeve or approved equal.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each through-penetration firestop system, show each type of construction condition penetrated, relationships to adjoining construction and type of penetrating item. Include firestop design designation of qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.

1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetrating items.
2. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular through-penetration firestop condition, submit illustration, with modifications marked, approved by through-penetration firestop system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

C. Through-Penetration Firestop System Schedule: Indicate locations of each through-penetration firestop system, along with the following information:

1. Types of penetrating items.
2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
3. Through-penetration firestop systems for each location identified by firestop design designation of qualified testing and inspecting agency.

D. Qualification Data: For Installer.

E. Product Certificates: For through-penetration firestop system products, signed by product manufacturer.

F. Product Test Reports: From a qualified testing agency indicating through-penetration firestop system complies with requirements, based on comprehensive testing of current products.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FMG according to FMG 4991, "Approval of Firestop Contractors."

B. Installer Qualifications: A firm experienced in installing through-penetration firestop systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its through-penetration firestop system products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.

C. Installation Responsibility: Assign installation of through-penetration firestop systems and fire-resistive joint systems in Project to a single qualified installer.

D. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, through one source from a single manufacturer.

E. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in Part 1 "Performance Requirements" Article:

1. Firestopping tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is Underwriter's Laboratories (UL), or another agency performing testing and follow-up inspection services for firestop systems acceptable to COR.
2. Through-penetration firestop systems are identical to those tested per testing standard referenced in "Part 1 Performance Requirements" Article. Provide rated systems complying with the following requirements:

   a. Through-penetration firestop system products bear classification marking of qualified testing and inspecting agency.
   b. Through-penetration firestop systems correspond to those indicated by reference to through-penetration firestop system designations listed by the following:

      1) UL in its "Fire Resistance Directory."
      2) OPL in its "Directory of Listed Building Products, Materials, & Assemblies."
      3) ITS in its "Directory of Listed Products."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life if applicable, qualified testing and inspecting agency's classification marking applicable to Project, curing time, and mixing instructions for multicomponent materials.

B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through-penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.7 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

C. Notify FAA's inspecting agency at least seven days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by COR.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, through-penetration firestop systems that may be incorporated into the Work include, but are not limited to, those systems indicated in the following section “Products.”

B. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers:

1. A/D Fire Protection Systems Inc.
2. Grace, W. R. & Co. - Conn.
3. Hilti, Inc.
4. Johns Manville.
5. Nelson Firestop Products.
6. NUCO Inc.
7. RectorSeal Corporation (The).
8. Specified Technologies Inc.
9. 3M; Fire Protection Products Division.
10. Tremco; Sealant/Weatherproofing Division.
11. USG Corporation.

2.2 FIRESTOPPING, GENERAL

A. Compatibility: Provide through-penetration firestop systems that are compatible with one another; with the substrates forming openings; and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

B. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with Part 1 "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by qualified testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:

1. Permanent forming/damming/backing materials, including the following:

    a. Slag-/rock-wool-fiber insulation.
    b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
    c. Fire-rated form board.
    d. Fillers for sealants.

2. Temporary forming materials.
3. Substrate primers.
4. Collars.
5. Steel sleeves.

2.3 FILL MATERIALS

A. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 by referencing the types of materials described in this Article. Fill materials are those referred to in directories of referenced testing and inspecting agencies as "fill," "void," or "cavity" materials.

B. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

C. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture.

D. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

E. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.

F. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

G. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.

H. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.

I. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives.

J. Intumescent Bricks: Expandable, flexible foam firestop brick capable of being stacked for larger openings.

K. High Traffic Cable Pathway: Self-contained system that adjusts to cables, steel construction with intumescent lining capable of preventing the spread of fire and smoke.

L. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

M. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces, and nonsag formulation for openings in vertical and other surfaces requiring a nonslumping, gunnable sealant, unless indicated firestop system limits use to nonsag grade for both opening conditions.
2. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
3. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

2.4 MIXING

A. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with firestop system manufacturer's written instructions and with the following requirements:

1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove tape as soon as possible without disturbing firestop system's seal with substrates.

3.3 THROUGH-PENETRATION FIRESTOP SYSTEM INSTALLATION

A. General: Install through-penetration firestop systems to comply with PART 1 "PERFORMANCE REQUIREMENTS" Article and with firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.

C. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 IDENTIFICATION

A. Identify through-penetration firestop systems with preprinted labels. Attach labels permanently to surfaces adjacent to and within 6 inches of edge of the firestop systems so that labels will be visible to anyone seeking to remove penetrating items or firestop systems. Use mechanical fasteners for metal labels. For plastic or paper labels, use self-adhering type with adhesives capable of permanently bonding labels to surfaces on which labels are placed and, in combination with label material, will result in partial destruction of label if removal is attempted. Include the following information on labels:

1. The words "Warning - Through-Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number.
3. Through-penetration firestop system designation of applicable testing and inspecting agency.
4. Date of installation.
5. Through-penetration firestop system manufacturer's name.
6. Installer's name.

3.5 FIELD QUALITY CONTROL

A. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements.

B. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.

3.6 CLEANING AND PROTECTING

A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

END OF SECTION 07 84 13

SECTION 07 92 00 - JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes low-VOC and Low-Odor joint sealants for the following locations:

1. Interior joints in vertical surfaces.

   a. Perimeter joints between interior wall surfaces and frames of interior doors.
   b. Tile wall and floor joints.
   c. Perimeter joints between existing exterior metal siding, and louver and window unit systems.
   d. Other joints as indicated.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide elastomeric joint sealants that have been produced and installed to establish and to maintain watertight and airtight continuous seals without causing staining or deterioration of joint substrates.

B. Provide joint sealants for interior applications that have been produced and installed to establish and maintain airtight continuous seals that are water resistant and cause no staining or deterioration of joint substrates.

C. Provide products that will not produce off-gassing of VOC's after product is installed and properly cured.

1.3 SUBMITTALS

A. Product data from manufacturers for each joint sealant product required.

1. Certification by joint sealant manufacturer that sealants plus the primers and cleaners required for sealant installation comply with local regulations controlling use of volatile organic compounds.
2. Provide Material Safety Data Sheets (MSDS) for the following:

   a. Elastomeric joint sealants
   b. Primer.
   c. Cleaners for nonporous surfaces.

B. Samples for initial selection purposes in form of manufacturer's standard bead samples, consisting of strips of actual products showing full range of colors available, for each product exposed to view.

C. Certificates from manufacturers of joint sealants attesting that their products comply with specification requirements and are suitable for the use indicated.

D. Qualification data complying with requirements specified in "QUALITY ASSURANCE" article. Include list of completed projects with project names addresses, names of architects and owners, plus other information specified.

E. Compatibility and adhesion test reports from elastomeric sealant manufacturer indicating that materials forming joint substrates and joint sealant backings have been tested for compatibility and adhesion with joint sealants. Include sealant manufacturer's interpretation of test results relative to sealant performance and recommendations for primers and substrate preparation needed to obtain adhesion.

F. Product test reports for each type of joint sealants indicated, evidencing compliance with requirements specified.

G. Preconstruction field test reports, indicating which products and joint preparation methods demonstrate acceptable adhesion to joint substrates.

H. Refer to Section “OPERATION AND MAINTENANCE DATA”.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who has completed joint sealant applications similar in material, design, and extent to that indicated for Project that have resulted in construction with a record of successful in-service performance.

B. Single Source Responsibility for Joint Sealant Materials: Obtain joint sealants and joint backer materials from a single manufacturer for each different product required.

C. Conduct Testing: Provide comprehensive test data for each type of joint sealant based on tests conducted by a qualified independent testing laboratory on current product formulations within a 24-month period preceding date of Contractor's submittal of test results to COR.

1. Test elastomeric sealants for compliance with requirements specified by reference to ASTM C920. Include test results for hardness, stain resistance, adhesion and cohesion under cyclic movement (per ASTM C719), low-temperature flexibility, modulus of elasticity at 100 percent strain, effects of heat aging, and effects of accelerated weathering.
2. Include test results performed on joint sealants after they have cured for 1 year.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle materials in compliance with manufacturer's recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.6 PROJECT CONDITIONS

A. Environmental Conditions: Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside the limits permitted by joint sealant manufacturer or below 40 deg F.
2. When joint substrates are wet.

B. Joint Width Conditions: Do not proceed with installation of joint sealants where joint widths are less than allowed by joint sealant manufacturer for application indicated.

C. Joint Substrate Conditions: Do not proceed with installation of joint sealants until contaminants capable of interfering with their adhesion are removed from joint substrates.

1.7 SEQUENCING AND SCHEDULING

A. Sequence installation of joint sealants to occur not less than 21 nor more than 30 calendar days after completion of waterproofing, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, joint fillers, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.

B. Colors: Provide selections made by COR from manufacturer's full range of standard colors for typical applications.

C. Provide VOC-compliant sealants. Products must not produce off-gassing after proper curing is achieved.

2.2 ELASTOMERIC JOINT SEALANTS

A. Elastomeric Sealant Standard: Provide manufacturer's standard chemically curing elastomeric sealants that comply with ASTM C 920.

B. Neutral-curing silicone as follows:

1. VOC Content: 0 g/L or 0 lbs. Per gallon less water and exempt solvents.
2. Type: Type S (ASTM C 920).
3. Grade NS (ASTM C 920).

4. Class: 25 (ASTM C 920).
5. Use: NT, A and M.
6. Shore A Hardness: 30 (ASTM D 2240)
7. Joint Movement Capability (after 14 cure days): Extension: 25%. Compression: 25%.
8. Tear Resistance: 18pli (ASTM D 624).
9. Elongation at Break: 320 percent (ASTM D 412).
10. Tensile Strength: 275psi (ASTM D 412).
11. Uses Related to Joint Substrates. Expansion and control joints in concrete and masonry; metal curtain walls, perimeter caulking of windows; conventional glazing. Adheres to metal, aluminum, galvanized steel, concrete and masonry. For exterior applications.
12. Available Products: Including but not limited to the following:

    a. Sonolastic OmniSeal by Sonneborn, ChemRex Inc., 889 Valley Park Drive, Shakopee, MN 55379

C. Multi-purpose mildew-resistant silicone sealant:

1. VOC Content: 0 g/L or 0 lbs. per gallon less water and exempt solvents.
2. Type: Type S (ASTM C 920).
3. Grade NS (ASTM C 920).
4. Class: 25 (ASTM C 920).
5. Use: NT, G and A.
6. Shore A Hardness: 25 (ASTM C 661).
7. Ultimate Elongation: 425 percent (ASTM D 412)
8. Tensile Strength, psi: 330 (ASTM D 412)
9. Movement Capability: 25 (ASTM C 719).
10. Extrusion Rate: 350 g/min.
11. Use Related to Exposure: NT (non-traffic).
12. Uses Related to Joint Substrates: Glass, Aluminum, Tile, Fiberglass, Countertops, Nonstructural glazing. For interior and exterior applications.
13. Available Products: Including but not limited to the following:

    a. Sonolastic OmniPlus by Sonneborn, ChemRex Inc., 889 Valley Park Drive, Shakopee, MN 55379

D. Low-Modulus, high-movement, fast-curing sealant:

1. VOC Content: 2.07 g/L or 0.02 lbs. per gallon. Complies with low-VOC regulations.
2. Type: S (ASTM C 920).
3. Grade: NS (ASTM C 290).
4. Class: 25 (ASTM C 290).
5. Use: NT, M, A, G and O.
6. Tensile Strength: 290 psi (ASTM D 412).
7. Ultimate Elongation at Break: 865 percent (ASTM D 412).
8. Hardness, Shore A: 20 (ASTM C 661).
9. Tear Strength: 70 lb/in (ASTM D 1004).
10. Use: Glass, aluminum, concrete, masonry, wood, stone, curtain wall construction, expansion wall joints. Interior and exterior use. Do not use on horizontal traffic-bearing surfaces.

11. Available Products:

    a. Sonolastic 150 by Sonneborn, ChemRex, Inc. 889 Valley Park Drive, Shakopee, MN 55379.

2.3 ELECTRICAL CONDUIT DUCT SEAL

A. Expandable foam duct sealant kits to prevent water and gas from entering manholes, vaults, or structures from electrical conduits.

    1. Seal all conduits that are underground, and conduits that run outside of structure.

B. Manufacturer: 3M “Scotchcast 4416 Duct Sealing Kit” or equal.

2.4 JOINT SEALANT BACKING

A. General: Provide sealant backings of material and type that are non-staining; are compatible with joint substrates, sealants, primers and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing. Provide backing and filler material by sealant manufacturer to greatest extent possible, or products recommended by sealant manufacturer.

B. Plastic Foam Joint Fillers: Preformed, compressible, resilient, non-staining, non-waxing, non-extruding strips of flexible plastic foam of material indicated below and of size, shape, and density to control sealant depth and otherwise contribute to producing optimum sealant performance:

    1. Open-cell polyurethane foam.
    2. Closed-cell polyethylene foam, nonabsorbent to liquid water and gas, non-outgassing in unruptured state.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape as recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

2.5 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint sealant-substrate tests and field tests.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming in any way joint substrates and adjacent nonporous surfaces, and formulated to promote optimum adhesion of sealants with joint substrates.

C. Masking Tape: Non-staining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint sealant performance. Do not proceed with installation of joint sealants until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with recommendations of joint sealant manufacturer and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
2. Clean concrete, masonry, unglazed surfaces of ceramic tile, and similar porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining from above cleaning operations by vacuuming or blowing out joints with oil-free compressed air.
3. Clean metal, glass and other nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.

B. Joint Priming: Prime joint substrates where indicated or where recommended by joint sealant manufacturer based on preconstruction joint sealant-substrate tests or prior experience. Apply primer to comply with joint sealant manufacturer's recommendations. Confine primers to areas of joint sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint sealant manufacturer's printed installation instructions applicable to products and applications indicated, except where more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations of ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Installation of Sealant Backings: Install sealant backings to comply with the following requirements:

1. Install joint fillers of type indicated to provide support of sealants during application and at position required to produce the cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

   a. Do not leave gaps between ends of joint fillers.
   b. Do not stretch, twist, puncture, or tear joint fillers.
   c. Remove absorbent joint fillers that have become wet prior to sealant application and replace with dry material.

2. Install bond breaker tape between sealants where backer rods are not used between sealants and joint fillers or back of joints.

D. Installation of Sealants: Install sealants by proven techniques that result in sealants directly contacting and fully wetting joint substrates, completely filling recesses provided for each joint configuration, and providing uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability. Install sealants at the same time sealant backings are installed.

E. Tooling of Non-sag Sealants: Immediately after sealant application and prior to time skinning or curing begins, tool sealants to form smooth, uniform beads of configuration indicated, to eliminate air pockets, and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

1. Provide concave joint configuration per Figure 5A in ASTM C1193, unless otherwise indicated.
2. Use masking tape to protect adjacent surfaces of recessed tooled joints.

3.4 CLEANING

A. Clean off excess sealants or sealant smears adjacent to joints as work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances or from damage resulting from construction operations or other causes so that they are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so that installations with repaired areas are indistinguishable from original work.

END OF SECTION 07 92 00

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SECTION 07 95 00 - EXPANSION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Architectural joint systems for building interiors.
2. Architectural joint systems for building exteriors.

1.2 DEFINITIONS

A. Maximum Joint Width: Widest linear gap a joint system tolerates and in which it performs its designed function without damaging its functional capabilities.

B. Minimum Joint Width: Narrowest linear gap a joint system tolerates and in which it performs its designed function without damaging its functional capabilities.

C. Movement Capability: Value obtained from the difference between widest and narrowest widths of a joint opening typically expressed in numerical values (mm or inches) or a percentage (plus or minus) of nominal value of joint width.

D. Nominal Joint Width: The width of the linear opening specified in practice and in which the joint system is installed.

1.3 SUBMITTALS

A. Shop Drawings: Provide the following for each joint system specified:

1. Placement Drawings: Include line diagrams showing plans, elevations, sections, details, splices, block out requirement, entire route of each joint system, and attachments to other work. Where joint systems change planes, provide isometric or clearly detailed drawing depicting how components interconnect.
2. Architectural Joint System Schedule: Prepared by or under the supervision of the supplier. Include the following information in tabular form:

   a. Manufacturer and model number for each joint system.
   b. Joint system location cross-referenced to Drawings.
   c. Nominal joint width.
   d. Movement capability.
   e. Classification as thermal or seismic.
   f. Materials, colors, and finishes.
   g. Product options.
   h. Fire-resistance ratings.

B. Samples for Initial Selection: For each type of joint system indicated.

1. Include manufacturer's color charts showing the full range of colors and finishes available for each exposed metal and elastomeric seal material.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for current products.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

B. Source Limitations: Obtain architectural joint systems through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of architectural joint systems and are based on the specific systems indicated. Refer to Division 01 Section "Product Requirements."

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

D. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines (ADAAG)".

E. Fire-Test-Response Characteristics: Where indicated, provide architectural joint system and fire-barrier assemblies identical to those of assemblies tested for fire resistance per UL 2079 or ASTM E 1966 by a testing and inspecting agency acceptable to authorities having jurisdiction.

1. Hose Stream Test: Wall-to-wall and wall-to-ceiling assemblies shall be subjected to hose stream testing.

1.5 COORDINATION

A. Coordinate installation of exterior wall and soffit joint systems with roof expansion assemblies to ensure that wall transitions are watertight. Roof expansion assemblies are specified in Division 07.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum: ASTM B 221, Alloy 6063-T5 for extrusions; ASTM B 209, Alloy 6061-T6 for sheet and plate.

1. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious materials.
2. High-Performance Organic Finish (Two-Coat Fluoropolymer): AA-C12C40R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: conversion

coating; Organic Coating: manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with AAMA 2604 and with coating and resin manufacturers' written instructions.

B. Elastomeric Seals: Preformed elastomeric membranes or extrusions to be installed in metal frames.

C. Compression Seals: ASTM E 1612; preformed rectangular elastomeric extrusions having internal baffle system and designed to function under compression.

D. Strip Seals: ASTM E 1783; preformed elastomeric membrane or tubular extrusions having an internal baffle system and secured in or over a joint by a metal locking rail.

E. Cellular Foam Seals: Extruded, compressible foam designed to function under compression.

F. Elastomeric Concrete: Modified epoxy or polyurethane extended into a prepackaged aggregate blend, specifically designed for bonding to concrete substrates.

G. Fire Barriers: Any material or material combination, when fire tested after cycling, designated to resist the passage of flame and hot gases through a movement joint and to meet performance criteria for required rating period.

H. Moisture Barrier: Flexible elastomeric material, EPDM, minimum 45 mils thick

I. Accessories: Manufacturer's standard anchors, clips, fasteners, set screws, spacers, and other accessories compatible with material in contact, as indicated or required for complete installations.

2.2 ARCHITECTURAL JOINT SYSTEMS, GENERAL

A. General: Provide architectural joint systems of design, basic profile, materials, and operation indicated. Provide units with capability to accommodate variations in adjacent surfaces.

1. Furnish units in longest practicable lengths to minimize field splicing. Install with hairline mitered corners where joint changes direction or abuts other materials.
2. Include factory-fabricated closure materials and transition pieces, tee-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous joint systems.

B. Design architectural joint systems for the following size and movement characteristics:

1. Nominal Joint Width: As indicated on Drawings.
2. Maximum Joint Width: As indicated on Drawings
3. Minimum Joint Width: As indicated on Drawings.
4. Movement Capability: Plus or minus 50 percent.
5. Type of Movement: Thermal and Wind sway.

2.3 ARCHITECTURAL JOINT SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Architectural Art Mfg., Inc.
2. Balco, Inc.
3. Construction Specialties, Inc.
4. Emseal Joint Systems LTD.
5. Joint Master/InPro Corporation.
6. Michael Rizza Company, LLC.
7. MM Systems Corporation.
8. Nystrom, Inc.
9. Watson Bowman Acme Corp.

B. Floor-to-Floor Joint Systems:

1. Type: Elastomeric Dual elastomeric seal.

a. Exposed Metal: Aluminum.

1) Finish: Manufacturer's standard finish.

b. Seal Material: Santoprene

1) Color: As selected by COR from manufacturer's full range.

2. Cover-Plate Design: Recessed to accept field-applied finish materials.

a. Recess Depth: As required to accommodate adjacent flooring.

3. Attachment Method: Mechanical anchors
4. Load Capacity: Standard duty.
5. Fire-Resistance Rating: Provide joint system and fire-barrier assembly with a rating not less than that of adjacent construction.
6. Moisture Barrier: Manufacturer's standard.

C. Floor-to-Wall Joint Systems:

1. Type: Elastomeric seal.

a. Exposed Metal: Aluminum.

1) Finish: Manufacturer's standard finish.

b. Seal Material: Santoprene

1) Color: As selected by COR from manufacturer's full range

2. Cover-Plate Design: Recessed to accept field-applied finish materials.

a. Recess Depth: As required to accommodate adjacent flooring.

3. Attachment Method: Mechanical anchors
4. Fire-Resistance Rating: Provide joint system and fire-barrier assembly with a rating not less than that of adjacent construction.
5. Moisture Barrier: Manufacturer's standard.

D. Wall-to-Wall Joint Systems:

1. Type: Elastomeric seal:

a. Exposed Metal: Aluminum:

1) Finish: Manufacturer's standard finish.

b. Seal Material: Santoprene:

1) Color: As selected by COR from manufacturer's full range

2. Fire-Resistance Rating: Provide joint system and fire-barrier assembly with a rating not less than that indicated that of adjacent construction.
3. Moisture Barrier: Manufacturer's standard.

E. Wall-to-Ceiling Joint Systems:

1. Type: Glide plate.

a. Exposed Metal: Aluminum.

1) Finish: Manufacturer's standard finish.

2. Fire-Resistance Rating: Provide joint system and fire-barrier assembly with a rating not less than that of adjacent construction.
3. Moisture Barrier: Manufacturer's standard.

2.4 FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces where architectural joint systems will be installed for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to architectural joint system manufacturer's written instructions.

B. Repair concrete slabs using manufacturer's recommended repair grout of compressive strength adequate for anticipated structural loadings.

C. Coordinate and furnish anchorages, setting drawings, and instructions for installing joint systems. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of joint systems.

D. Cast-In Frames: Coordinate and furnish frames to be cast into concrete.

3.3 INSTALLATION

A. Comply with manufacturer's written instructions for storing, handling, and installing architectural joint assemblies and materials unless more stringent requirements are indicated.

B. Metal Frames: Perform cutting, drilling, and fitting required to install joint systems.

1. Install in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
2. Adjust for differences between actual structural gap and nominal design gap due to ambient temperature at time of installation. Notify Architect where discrepancies occur that will affect proper joint installation and performance.
3. Cut and fit ends to accommodate thermal expansion and contraction of metal without buckling of frames.
4. Locate in continuous contact with adjacent surfaces.
5. Standard-Duty Systems: Shim to level where required. Support underside of frames continuously to prevent vertical deflection when in service.
6. Heavy-Duty Systems: Repair or grout block out as required for continuous frame support and to bring frame to proper level. Shimming is not allowed.
7. Locate anchors at interval recommended by manufacturer, but not less than 3 inches from each end and not more than 24 inches o.c.

C. Seals in Metal Frames: Install elastomeric seals and membranes in frames to comply with manufacturer's written instructions. Install with minimum number of end joints.

1. Provide in continuous lengths for straight sections.
2. Seal transitions according to manufacturer's written instructions. Vulcanize or heat-weld field-spliced joints as recommended by manufacturer.

3. Installation: Mechanically lock seals into frames or adhere to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.

D. Terminate exposed ends of joint assemblies with field- or factory-fabricated termination devices.

E. Fire-Resistance-Rated Assemblies: Coordinate installation of architectural joint assembly materials and associated work so complete assemblies comply with assembly performance requirements.

1. Fire Barriers: Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of joint, including transitions and field splices.

F. Water Barrier: Provide water barrier at exterior joints and where called for on Drawings. Provide drainage fittings at a maximum of 50 feet or where indicated.

3.4 PROTECTION

A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.

B. Protect the installation from damage by work of other Sections. Where necessary due to heavy construction traffic, remove and properly store cover plates or seals and install temporary protection over joints. Reinstall cover plates or seals prior to Substantial Completion of the Work.

END OF SECTION 07 95 00

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SECTION 08 11 13 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior standard hollow metal doors and frames.

2. Exterior standard hollow metal doors and frames.

1.2 DEFINITIONS

A. Minimum Thickness: Minimum thickness of base metal without coatings.

B. Standard Hollow Metal Work: Hollow metal work fabricated according to ANSI/SDI A250.8.

C. Custom Hollow Metal Work: Hollow metal work fabricated according to ANSI/NAAMM-HMMA 861.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, core descriptions, fire-resistance rating, and finishes.

B. Shop Drawings: Include the following:

1. Elevations of each door design.
2. Details of doors, including vertical and horizontal edge details and metal thicknesses.
3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
4. Locations of reinforcement and preparations for hardware.
5. Details of each different wall opening condition.
6. Details of anchorages, joints, field splices, and connections.
7. Details of accessories.
8. Details of moldings, removable stops, and glazing.
9. Details of conduit and preparations for power, signal, and control systems.

C. Oversize Construction Certification: For assemblies required to be fire rated and exceeding limitations of labeled assemblies.

D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each type of hollow metal door and frame assembly.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain hollow metal work from single source from single manufacturer.

B. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing as close to neutral pressure as possible according to NFPA 252 or UL 10B.

1. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
2. Temperature-Rise Limit: Where indicated At vertical exit enclosures and exit passageways, provide doors that have a maximum transmitted temperature end point of not more than 450 deg F above ambient after 30 minutes of standard fire-test exposure.

C. Fire-Rated, Borrowed-Light Frame Assemblies: Assemblies complying with NFPA 80 that are listed and labeled, by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9 UBC Standard 7-4. Label each individual glazed lite.

D. Smoke-Control Door Assemblies: Comply with NFPA 105 or UL 1784.

E. Preinstallation Conference: Conduct conference at Project site.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver hollow metal work palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.

1. Provide additional protection to prevent damage to finish of factory-finished units.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

C. Store hollow metal work under cover at Project site. Place in stacks of five units maximum in a vertical position with heads up, spaced by blocking, on minimum 4-inch- high wood blocking. Do not store in a manner that traps excess humidity.

1. Provide minimum 1/4-inch space between each stacked door to permit air circulation.

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.7 COORDINATION

A. Coordinate installation of anchorages for hollow metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Amweld Building Products, LLC.
2. Benchmark; a division of Therma-Tru Corporation.
3. Ceco Door Products; an Assa Abloy Group company.
4. Curries Company; an Assa Abloy Group company.
5. Deansteel Manufacturing Company, Inc.
6. Firedoor Corporation.
7. Fleming Door Products Ltd.; an Assa Abloy Group company.
8. Habersham Metal Products Company.

2.2 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

B. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

C. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum A40 G60 or A60 metallic coating.

D. Frame Anchors: ASTM A 591/A 591M, Commercial Steel (CS), 40Z coating designation; mill phosphatized.

1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.

E. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.

F. Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow metal frames of type indicated.

G. Grout: ASTM C 476, except with a maximum slump of 4 inches, as measured according to ASTM C 143/C 143M.

H. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool with 6- to 12-lb/cu. ft. density; with maximum flame-spread and smoke-development indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.

I. Glazing: Comply with requirements in Section 08 80 00 "GLAZING".

J. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.3 STANDARD HOLLOW METAL DOORS (SEEL DOORS)

A. General: Provide doors of design indicated, not less than thickness indicated; fabricated with smooth surfaces, without visible joints or seams on exposed faces unless otherwise indicated. Comply with ANSI/SDI A250.8.

1. Design: Flush panel
2. Core Construction: Manufacturer's standard kraft-paper honeycomb, polystyrene, polyurethane, polyisocyanurate, mineral-board, or vertical steel-stiffener core.

   a. Fire Door Core: As required to provide fire-protection ratings indicated.
   b. Thermal-Rated (Insulated) Doors: Where indicated, provide doors fabricated with thermal-resistance value (R-value) of not less than 4.0 deg F x h x sq. ft./Btu when tested according to ASTM C 1363.

      1) Locations: Exterior doors and interior doors where indicated.

3. Vertical Edges for Single-Acting Doors: Manufacturer's standard.

   a. Beveled Edge: 1/8 inch in 2 inches.

4. Vertical Edges for Double-Acting Doors: Round vertical edges with 2-1/8-inch radius.
5. Top and Bottom Edges: Closed with flush or inverted 0.042-inch- thick, end closures or channels of same material as face sheets.
6. Tolerances: Comply with SDI 117, "Manufacturing Tolerances for Standard Steel Doors and Frames."
7. SDI A250.8, except as specified otherwise. Prepare doors to receive hardware specified in section 08 71 00 DOOR HARDWARE. Undercut where indicated. Exterior doors shall have top edge closed flush and sealed to prevent water intrusion. Doors shall be 1 ¾ inches think unless otherwise indicated
8. Classification: Level, Performance, Model

B. Exterior Doors: Face sheets fabricated from metallic-coated steel sheet. Provide doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:

1. Level 2 and Physical Performance Level B (Heavy Duty), Model 2 (Seamless)
2. Level 3 and Physical Performance Level A (Extra Heavy Duty), Model 2 (Seamless)
3. Level 4 and Physical Performance Level A (Maximum Duty), Model 2 (Seamless).

C. Interior Doors: Face sheets fabricated from cold-rolled steel sheet. Provide doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:

1. Level 2 and Physical Performance Level B (Heavy Duty), Model 2 (Seamless) – Interior Doors, unless noted otherwise.

2. Level 3 and Physical Performance Level A (Extra Heavy Duty), Model 2 (Seamless) – Secure Interior Doors, unless noted otherwise.
3. Level 4 and Physical Performance Level A (Maximum Duty), Model 2 (Seamless) – Link Doors, unless noted otherwise.

D. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcing plates from same material as door face sheets.

E. Fabricate concealed stiffeners and hardware reinforcement from either cold- or hot-rolled steel sheet.

2.4 STANDARD HOLLOW METAL FRAMES

A. General: Comply with ANSI/SDI A250.8 and with details indicated for type and profile.

B. Exterior Frames (Blast Resistant Doors, Section 08 39 54): Integral Door/Frame Assembly.

C. Exterior Frames: Fabricated from metallic-coated steel sheet.

1. Fabricate frames with mitered or coped corners.
2. Fabricate frames full profile welded unless otherwise indicated.
3. Frames for Level 2 Steel Doors: 0.053-inch- thick steel sheet.
4. Frames for Level 3 Steel Doors: 0.053-inch- thick steel sheet.
5. Frames for Level 4 Steel Doors: 0.067-inch- thick steel sheet.

D. Interior Frames: Fabricated from cold-rolled steel sheet.

1. Fabricate frames with mitered or coped corners.
2. Fabricate frames as knocked down unless otherwise indicated.
3. Fabricate knocked-down, drywall slip-on frames for in-place gypsum board partitions.
4. Frames for Level 2 Steel Doors: 0.053-inch- thick steel sheet.
5. Frames for Level 3 Steel Doors: 0.053-inch- thick steel sheet.
6. Frames for Level 4 Steel Doors: 0.067-inch- thick steel sheet.
7. Frames for Borrowed Lights: Same as adjacent door frame.

E. Cased Openings: Fabricate frames for cased openings of same material, gage, and assembly as specified for metal door frames, except omit door stops and preparation for hardware.

F. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcement plates from same material as frames.

2.5 FRAME ANCHORS

A. Jamb Anchors:

1. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.042 inch thick, with corrugated or perforated straps not less than 2 inches wide by 10 inches long; or wire anchors not less than 0.177 inch thick.
2. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042 inch thick.

3. Compression Type for Drywall Slip-on Frames: Adjustable compression anchors.
4. Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch-diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.

B. Floor Anchors: Formed from same material as frames, not less than 0.042 inch thick, and as follows:

1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
2. Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch height adjustment. Terminate bottom of frames at finish floor surface.

2.6 HOLLOW METAL PANELS

A. Provide hollow metal panels of same materials, construction, and finish as specified for adjoining hollow metal work.

2.7 ASTRAGALS AND REMOVABLE MULLIONS

A. Pairs of interior doors shall be fabricated with steel astragals.

B. Pairs of exterior doors shall be fabricated to accommodate keyed removable mullions.

2.8 STOPS AND MOLDINGS

A. Moldings for Glazed Lites in Doors: Minimum 0.032 inch thick, fabricated from same material as door face sheet in which they are installed. Provide nonremovable moldings on outside of exterior doors and on corridor side of interior doors. Other moldings may be stationary or removable. Secure inside moldings to stationary moldings, or provide snap-on moldings. Muntins shall interlock at intersections and shall be fitted and welded to stationary moldings.

B. Fixed Frame Moldings: Formed integral with hollow metal frames, a minimum of 5/8 inch high unless otherwise indicated.

C. Loose Stops for Glazed Lites in Frames: Minimum 0.032 inch thick, fabricated from same material as frames in which they are installed.

2.9 LOUVERS

A. Provide louvers for doors, where indicated, that comply with SDI 111C, with blades or baffles formed of 0.020-inch- thick, cold-rolled steel sheet set into 0.032-inch- thick steel frame.

1. Sightproof Louver: Stationary louvers constructed with inverted V-shaped blades, with minimum 55% net-free opening.
2. Lightproof Louver: Stationary louvers constructed with baffles to prevent light from passing from one side to the other, any angle.
3. Fire-Rated Automatic Louvers: Louvers constructed with movable blades closed by actuating fusible link, and listed and labeled for use in fire-rated door assemblies of type

and fire-resistance rating indicated by same testing and inspecting agency that established fire-resistance rating of door assembly.

4. Exterior Louvers: Weld or tenon louver blades to cont. Channel frame and weld assembly to door to form watertight assembly. Shall have steel framed insect screens secured to room side and readily removable aluminum wire cloth, 18x18 or 18x16 inch mesh.

2.10 ACCESSORIES

A. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.

B. Ceiling Struts: Minimum 1/4-inch-thick by 1-inch- wide steel.

C. Grout Guards: Formed from same material as frames, not less than 0.016 inch thick.

2.11 FABRICATION

A. Fabricate hollow metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.

B. Tolerances: Fabricate hollow metal work to tolerances indicated in SDI 117.

C. Hollow Metal Doors:

1. Exterior Doors: Provide weep-hole openings in bottom of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration.
2. Glazed Lites: Factory cut openings in doors.
3. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch beyond edge of door on which astragal is mounted.

D. Hollow Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.

1. Welded Frames: Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible.
2. Sidelight and Transom Bar Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by butt welding.
3. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
4. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
5. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
6. Jamb Anchors: Provide number and spacing of anchors as follows:

a. Masonry Type: Locate anchors not more than 18 inches from top and bottom of frame. Space anchors not more than 32 inches o.c. and as follows:

1) Two anchors per jamb up to 60 inches high.
2) Three anchors per jamb from 60 to 90 inches high.
3) Four anchors per jamb from 90 to 120 inches high.
4) Four anchors per jamb plus 1 additional anchor per jamb for each 24 inches or fraction thereof above 120 inches high.

b. Stud-Wall Type: Locate anchors not more than 18 inches from top and bottom of frame. Space anchors not more than 32 inches o.c. and as follows:

1) Three anchors per jamb up to 60 inches high.
2) Four anchors per jamb from 60 to 90 inches high.
3) Five anchors per jamb from 90 to 96 inches high.
4) Five anchors per jamb plus 1 additional anchor per jamb for each 24 inches or fraction thereof above 96 inches high.
5) Two anchors per head for frames above 42 inches wide and mounted in metal-stud partitions.

c. Compression Type: Not less than two anchors in each jamb.
d. Postinstalled Expansion Type: Locate anchors not more than 6 inches from top and bottom of frame. Space anchors not more than 26 inches o.c.

7. Door Silencers: Except on weather-stripped doors, drill stops to receive door silencers as follows. Keep holes clear during construction.

a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

E. Fabricate concealed stiffeners, edge channels, and hardware reinforcement from either cold- or hot-rolled steel sheet.

F. Hardware Preparation: Factory prepare hollow metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to the Door Hardware Schedule and templates furnished as specified in Section 08 71 00 "DOOR HARDWARE."

1. Locate hardware as indicated, or if not indicated, according to ANSI/SDI A250.8.
2. Reinforce doors and frames to receive nontemplated, mortised and surface-mounted door hardware.
3. Comply with applicable requirements in ANSI/SDI A250.6 and ANSI/DHI A115 Series specifications for preparation of hollow metal work for hardware.
4. Coordinate locations of conduit and wiring boxes for electrical connections with Division 26 Sections.

G. Stops and Moldings: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with butted or mitered hairline joints.

1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow metal work.

2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
3. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
4. Provide loose stops and moldings on inside of hollow metal work.
5. Coordinate rabbet width between fixed and removable stops with type of glazing and type of installation indicated.

2.12 STEEL FINISHES

A. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.

1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for embedded and built-in anchors to verify actual locations before frame installation.

C. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.

B. Prior to installation, adjust and securely brace welded hollow metal frames for squareness, alignment, twist, and plumbness to the following tolerances:

1. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
2. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
3. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
4. Plumbness: Plus or minus 1/16 inch, measured at jambs on a perpendicular line from head to floor.

C. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.3 INSTALLATION

A. General: Install hollow metal work plumb, rigid, properly aligned, and securely fastened in place; comply with Drawings and manufacturer's written instructions.

B. Hollow Metal Frames: Install hollow metal frames of size and profile indicated. Comply with ANSI/SDI A250.11.

1. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.

   a. At fire-protection-rated openings, install frames according to NFPA 80.
   b. Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
   c. Install frames with removable glazing stops located on secure side of opening.
   d. Install door silencers in frames before grouting.
   e. Remove temporary braces necessary for installation only after frames have been properly set and secured.
   f. Check plumbness, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
   g. Field apply bituminous coating to backs of frames that are filled with grout containing antifreezing agents.

2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.

   a. Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.

3. Metal-Stud Partitions: Solidly pack mineral-fiber insulation behind frames.
4. Concrete Walls: Solidly fill space between frames and concrete with grout. Take precautions, including bracing frames, to ensure that frames are not deformed or damaged by grout forces.
5. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
6. In-Place Gypsum Board Partitions: Secure frames in place with postinstalled expansion anchors through floor anchors at each jamb. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
7. Ceiling Struts: Extend struts vertically from top of frame at each jamb to overhead structural supports or substrates above frame unless frame is anchored to masonry or to other structural support at each jamb. Bend top of struts to provide flush contact for securing to supporting construction. Provide adjustable wedged or bolted anchorage to frame jamb members.

8. Installation Tolerances: Adjust hollow metal door frames for squareness, alignment, twist, and plumb to the following tolerances:

   a. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
   b. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
   c. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
   d. Plumbness: Plus or minus 1/16 inch, measured at jambs at floor.

C. Hollow Metal Doors: Fit hollow metal doors accurately in frames, within clearances specified below. Shim as necessary.

1. Non-Fire-Rated Standard Steel Doors:

   a. Jambs and Head: 1/8 inch plus or minus 1/16 inch.
   b. Between Edges of Pairs of Doors: 1/8 inch plus or minus 1/16 inch.
   c. Between Bottom of Door and Top of Threshold: Maximum 3/8 inch.
   d. Between Bottom of Door and Top of Finish Floor (No Threshold): Maximum 3/4 inch.

2. Fire-Rated Doors: Install doors with clearances according to NFPA 80.
3. Smoke-Control Doors: Install doors according to NFPA 105.

D. Glazing: Comply with installation requirements in Section 08 80 00 "GLAZING" and with hollow metal manufacturer's written instructions.

1. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches o.c. and not more than 2 inches o.c. from each corner.

3.4 ADJUSTING AND CLEANING

A. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow metal work that is warped, bowed, or otherwise unacceptable.

B. Remove grout and other bonding material from hollow metal work immediately after installation.

C. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

END OF SECTION 08 11 13

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SECTION 08 14 16 - FLUSH WOOD DOORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solid-core doors with wood-veneer.
2. Shop priming and factory finishing flush wood doors.

1.2 SUBMITTALS

A. Product Data: For each type of door indicated. Include details of core and edge construction, louvers, and trim for openings.

B. Shop Drawings: Indicate location, size, and hand of each door; elevation of each kind of door; construction details not covered in Product Data; location and extent of hardware blocking; and other pertinent data.

1. Indicate dimensions and locations of mortises and holes for hardware.
2. Indicate dimensions and locations of cutouts.
3. Indicate requirements for veneer matching.
4. Indicate doors to be factory finished and finish requirements.
5. Indicate fire-protection ratings for fire-rated doors.

C. Samples for Initial Selection: For factory-finished doors.

D. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer that is certified for chain of custody by an FSC-accredited certification body.

B. Source Limitations: Obtain flush wood doors from single manufacturer.

C. Quality Standard: In addition to requirements specified, comply with WDMA I.S.1-A, "Architectural Wood Flush Doors.

1. Provide AWI Quality Certification Labels or an AWI letter of licensing for Project indicating that doors comply with requirements of grades specified.
2. Provide WI-Certified Compliance Certificate indicating that doors comply with requirements of grades specified.
3. Provide WI-Certified Compliance Certificate for installation.

D. Preinstallation Conference: Conduct conference at Project site.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of referenced standard and manufacturer's written instructions.

B. Package doors individually in cardboard cartons and wrap bundles of doors in plastic sheeting.

C. Mark each door on top and bottom rail with opening number used on Shop Drawings.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install doors until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace doors that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Warping (bow, cup, or twist) more than 1/4 inch in a 42-by-84-inch section.
    b. Telegraphing of core construction in face veneers exceeding 0.01 inch in a 3-inch span.

2. Warranty shall also include installation and finishing that may be required due to repair or replacement of defective doors.
3. Warranty Period for Solid-Core Interior Doors: Life of installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Algoma Hardwoods, Inc.
2. Ampco, Inc.
3. Buell Door Company Inc.
4. Chappell Door Co.
5. Eagle Plywood & Door Manufacturing, Inc.
6. Eggers Industries.
7. Graham; an Assa Abloy Group company.

8. Haley Brothers, Inc.
9. Ideal Architectural Doors & Plywood.
10. Ipik Door Company.
11. Lambton Doors.
12. Marlite.
13. Marshfield Door Systems, Inc.
14. Mohawk Flush Doors, Inc.; a Masonite company.
15. Oshkosh Architectural Door Company.
16. Poncraft Door Company.
17. Vancouver Door Company.
18. VT Industries Inc.

2.2 DOOR CONSTRUCTION, GENERAL

A. Low-Emitting Materials: Provide doors made with adhesives and composite wood products that do not contain urea formaldehyde.

B. WDMA I.S.1-A Performance Grade: Heavy Duty

C. Particleboard-Core Doors:

1. Particleboard: ANSI A208.1, Grade LD-1, made with binder containing no urea-formaldehyde resin.
2. Blocking: Provide 5-inch wood blocking in particleboard-core doors as needed to eliminate through-bolting hardware.

2.3 VENEERED-FACED DOORS FOR TRANSPARENT FINISH

A. Interior Solid-Core Doors :

1. Grade: Premium, with Grade A faces.
2. Species: Red oak
3. Cut: Rotary cut
4. Core: Particleboard
5. WDMA I.S.1-A Performance Grade: Heavy Duty

2.4 LOUVERS AND LIGHT FRAMES

A. Metal Louvers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Air Louvers Inc.
   b. Anemostat; a Mestek company.
   c. Hiawatha Incorporated.
   d. L & L Louvers, Inc.

e. LL Building Products, Inc.; a division of GAF Materials Corporation.
f. Louvers & Dampers, Inc.; a Mestek company.
g. McGill Architectural Products.

2. Blade Type: Vision-proof, inverted V
3. Metal and Finish: Hot-dip galvanized steel, 0.040 inch thick, factory primed with baked-enamel- or powder-coated finish.

2.5 FABRICATION

A. Factory fit doors to suit frame-opening sizes indicated. Comply with clearance requirements of referenced quality standard for fitting unless otherwise indicated.

B. Factory machine doors for hardware that is not surface applied. Locate hardware to comply with DHI-WDHS-3. Comply with final hardware schedules, door frame Shop Drawings, DHI A115-W series standards, and hardware templates.

C. Openings: Cut and trim openings through doors in factory.

1. Louvers: Factory install louvers in prepared openings.

2.6 SHOP PRIMING

A. Doors for Transparent Finish: Shop prime doors with stain (if required), other required pretreatments, and first coat of finish as specified in Section 09 91 00 "PAINTING". Seal all four edges, edges of cutouts, and mortises with first coat of finish.

2.7 FACTORY FINISHING

A. General: Comply with referenced quality standard for factory finishing. Complete fabrication, including fitting doors for openings and machining for hardware that is not surface applied, before finishing.

1. Finish faces, all four edges, edges of cutouts, and mortises. Stains and fillers may be omitted on top and bottom edges, edges of cutouts, and mortises.

B. Finish doors at factory.

C. Finish doors at factory that are indicated to receive transparent finish. Field finish doors indicated to receive opaque finish.

D. Finish doors at factory where indicated in schedules or on Drawings as factory finished.

E. Transparent Finish:

1. Grade: Custom.
2. Finish: AWI catalyzed polyurethane system.
3. Staining: As selected by Architect from manufacturer's full range.
4. Effect: Filled finish.
5. Sheen: Satin.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine doors and installed door frames before hanging doors.

1. Verify that frames comply with indicated requirements for type, size, location, and swing characteristics and have been installed with level heads and plumb jambs.
2. Reject doors with defects.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Hardware: For installation, see Section 08 71 00 "DOOR HARDWARE".

B. Installation Instructions: Install doors to comply with manufacturer's written instructions and the referenced quality standard, and as indicated.

C. Job-Fitted Doors: Align and fit doors in frames with uniform clearances and bevels as indicated below; do not trim stiles and rails in excess of limits set by manufacturer or permitted for fire-rated doors. Machine doors for hardware. Seal edges of doors, edges of cutouts, and mortises after fitting and machining.

1. Clearances: Provide 1/8 inch at heads, jambs, and between pairs of doors. Provide 1/8 inch from bottom of door to top of decorative floor finish or covering unless otherwise indicated. Where threshold is shown or scheduled, provide 1/4 inch from bottom of door to top of threshold unless otherwise indicated.

2. Bevel non-fire-rated doors 1/8 inch in 2 inches at lock and hinge edges.

D. Factory-Fitted Doors: Align in frames for uniform clearance at each edge.

E. Factory-Finished Doors: Restore finish before installation if fitting or machining is required at Project site.

3.3 ADJUSTING

A. Operation: Rehang or replace doors that do not swing or operate freely.

B. Finished Doors: Replace doors that are damaged or that do not comply with requirements. Doors may be repaired or refinished if work complies with requirements and shows no evidence of repair or refinishing.

END OF SECTION 08 14 16

SECTION 08 31 13 - ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Access doors and frames for walls and ceilings.

1.2 SUBMITTALS

A. Product Data: For each type of access door and frame indicated. Include construction details, fire ratings, materials, individual components and profiles, and finishes.

B. Shop Drawings:

1. Specifications relating door thickness, resin type, core material, method of construction, finish color, type of glass and glazing, anchor systems, joint construction and complete warranty information.
2. Complete schedules or drawings of doors and frames (and associated Builders Hardware) showing identifying mark numbers, door and frame types, typical elevations, nominal sizes, handing, actual dimensions and clearances, and required hardware preps and reinforcements.
3. Supporting reference drawings pertaining to frame mounting details, door light or louver installation, hardware locations, and factory hardware cutouts and reinforcements.

C. Samples: For each door face material, at least 3 by 5 inches in size, in specified finish.

D. Access Door and Frame Schedule: Provide complete access door and frame schedule, including types, locations, sizes, latching or locking provisions, and other data pertinent to installation.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of access door(s) and frame(s) through one source from a single manufacturer.

B. Fire-Rated Access Doors and Frames: Units complying with NFPA 80 that are identical to access door and frame assemblies tested for fire-test-response characteristics per the following test method and that are listed and labeled by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:

1. NFPA 252 for vertical access doors and frames.
2. ASTM E 119 for horizontal access doors and frames.

C. Size Variations: Obtain COR's acceptance of manufacturer's standard-size units, which may vary slightly from sizes indicated.

1.4 COORDINATION

A. Verification: Determine specific locations and sizes for access doors needed to gain access to concealed plumbing, mechanical, or other concealed work, and indicate in the schedule specified in "Submittals" Article.

1.5 DELIVERY, STORAGE & HANDLING

A. FRP doors and frames are delivered to your site in wooden boxes with foam sheet separations.

B. Upon receipt of shipment, remove and inspect the doors and frames for damage. Note any damage on the shipping papers prior to accepting. If there is any noted (visible or concealed) damage, notify the manufacturer immediately.

C. Handling and storage of the doors and frames after receipt is the responsibility/liability of the customer. It is recommended that the doors be stored indoors in a vertical position, clear of the floor, with blocking between the doors to permit air circulation between the doors and prevent damage to the door faces. Rain/water or condensation must not be allowed to collect or lay between stored doors. Do not wrap in plastic sheeting as it will promote condensation formation within. Permanent discoloration can result.

D. Use care in handling doors and frames to prevent damage to factory finishes. Wear protective gloves and do not slide or drag doors or frames against one another.

PART 2 - PRODUCTS

2.1 FIBERGLASS ACCESS DOORS AND FRAMES FOR WALLS

A. Available Manufacturers: Subject to compliance with requirements, the Basis of Design shall be but is not limited to the following:

1. FRP Doors and Frames shall be as manufactured by Tiger Door, Omaha, NE. 68102 Phone 888-891-4416.

B. Fire Rated RFP Doors:

1. Design: Fire rated FRP doors shall be of seamless press-molded construction. Laminated FRP face sheets shall be applied while wet and uncured to an internal door subframe/core assembly and then press-molded under heat and pressure. The composite door panel must be integrally fused over its entire surface area. Doors shall remain under pressure during curing for flat, warp-free surfaces.
2. Core: For maximum rigidity and compressive strength a fire resistant mineral core shall be used. Molding pressure and resin gel time shall be sufficient to allow for penetration of resin into the cellular structure of the core to maximize shear and peel strengths at the skin/core interface and reduce the possibility of delamination. The mineral core is to be completely enclosed within the intumescent and FRP laminated edge perimeter.
3. Intumescent: Only Category A type door construction is permitted. All intumescents shall be molded into the door structure with a minimum of 1/8” thick perimeter FRP edge

banding (prior to machining). Category B type door construction, with post applied and/or exposed edge intumescent components or products are not acceptable.

4. Faces: Door facings shall utilize a chemical resistant proprietary class I flame spread thermosetting polyester resin formulation with glass fiber reinforcing layers. Chopped strand mat layers shall be used to provide bond integrity between gelcoat, laminated facings and the internal door structure. Structural reinforcement shall be in the form of a knitted multi-layer material with layers of uni-directional glass fiber oriented in both the vertical and horizontal directions for high stiffness, impact resistance and resistance to warping.
5. Finish: The exposed FRP door faces must have either an integrally molded 25/30 mils thick (wet) ultraviolet light stabilized marine grade NPG-isophthalic polyester gelcoat or an industrial urethane chemical coating color topcoat. Gelcoated facings shall have a slightly textured semi-gloss finish to minimize the visual effects of wear and tear. Door face color shall be selected from the manufacturer's available colors. Gelcoat shall not be sprayed onto the door face as a secondary coating.
6. Astragals: Provide a heavy pultruded FRP angle astragal on the meeting stile edge of each inactive leaf of double door pairs.
7. Size limitations: The maximum double door jamb opening size shall not exceed nominal 8' – 0" x 8' – 0" with a Maximum single door panel size not to exceed nominal 4' – 0" x 8' – 0".

C. Fire Rated Frames:

1. 1. Design: Fire rated FRP Door frames furnished under this specification shall utilize a high-modulus pultruded structural FRP shape. Frame profile is a double rabbeted 4" depth x 1" face, 3/16" thick, with integral 5/8" doorstop. Four inch header and expanded profiles are acceptable. Frame cavities shall be filled with a proprietary fire resistant composite formulation with a minimum density of 25 lb/ft3. Hollow metal or Stainless Steel frames are not acceptable.
2. Intumescent: All intumescent material shall be internal to the door structure. Post applied or exposed intumescent components or products are not acceptable.
3. Corner Joints: Jambs and header shall be joined at corners via miter connections with hidden stainless steel flat head screws. Corner screws shall not be visible on interior or exterior frame faces.
4. Anchors:

   a. BOLT-IN: Provide 3/8" diameter x 5" expanding sleeve type for concrete walls per jamb side.
5. Finish: Frames shall have a factory applied industrial urethane chemical coating color topcoat, to match the color and sheen of the doors, for superior weatherability. Gelcoat may be sprayed onto the frame as a secondary coating if required.

2.2 MECHANICAL PROPERTIES & TEST PERFORMANCE

A. Pultruded structural shapes for edges, frames, and astragals shall exhibit the following minimum longitudinal coupon properties (per ASTM):

1. Tensile strength (D638) 30,000 psi
2. Comprehensive strength (D695) 30,000 psi

3. Flexural strength (D790) 30,000 psi
4. Flexural modulus (D790) 1,600,000 psi
5. Shear strength (D2846) 4,500 psi
6. Impact, notched (D256) 25 ft-lb/in
7. Barcol hardness (D2853) 50
8. Fire Resistance (E-84) Class I

B. Core material shall exhibit the following minimum properties:

1. Core material must comply with the International Building Code (IBC) chapter 26 requirements for use with a plastic skin.
2. Core material must be asbestos free incombustible mineral composition.

C. Core banding material shall exhibit the following minimum coupon properties (per ASTM):

1. Core banding material must comply with the International Building Code (IBC) chapter 26 requirements for use with a plastic skin.
2. Modulus of Rupture (C133) 1700 psi
3. Compressive Strength (C109-93) 2800 psi
4. Thermal Conductivity 946 F(C182) 1.38 (BTU-in/hr-ft$_2$-F)
5. Thermal Conductivity 1632 F (C182) 1.39 (BTU-in/hr-ft$_2$-F)
6. Shrinkage average % (C356) at 1200 F 24 hours -4.7%
7. Screw Holding 1100 lbs
8. Electrical Resistivity from ambient to 1148 F (D257) 3.40 E+10 ohm-cm 08300-5 FRP DOORS, FRAMES
9. Heat Transfer for unexposed surface rise above ambient 90 minute, 1772 F (E 152) 196 F
10. Density minimum 60 lb/ft3
11. Core banding material must be asbestos free incombustible mineral composition.

D. Adhesive for bonding pultrusions shall exhibit the following minimum coupon properties (per SAE)

1. Tensile Strength (D882-83A modified) minimum 2000 psi
2. 8 day 25º C at 100% humidity Cross Peel (SAE J1553) minimum 330 psi
3. 7 day immersion in seawater Cross Peel (SAE J1553) minimum 330 psi
4. 30 day immersion in saltwater Cross Peel (SAE J1553) minimum 330 psi
5. 72 hour immersion in gasoline Cross Peel (SAE J1553) minimum 330 psi
6. 72 hour immersion in 20% sulfuric acid Cross Peel (SAE J1553) minimum 300 psi

E. E. UL 10b, UL 10c / UBC7-2 positive pressure – Doors and Frames

1. Singles and pairs, with component listings for both FRP doors and FRP frames

F. F. UL 9, – Fixed Sash

1. Listing for Fiberglass fixed sash with FRP glazing stop.

2.3 FABRICATION

A. General: Provide access door and frame assemblies manufactured as integral units ready for installation.

B. Metal Surfaces: For metal surfaces exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

C. Doors and Frames: Grind exposed welds smooth and flush with adjacent surfaces. Furnish attachment devices and fasteners of type required to secure access panels to types of supports indicated.

1. Exposed Flanges: As indicated
2. For trimless frames with drywall bead, provide edge trim for gypsum board securely attached to perimeter of frames.
3. For trimless frames with plaster bead for full-bed plaster applications, provide zinc-coated expanded metal lath and exposed casing bead welded to perimeter of frames.
4. Provide mounting holes in frames for attachment of units to metal or wood framing.
5. Provide mounting holes in frame for attachment of masonry anchors.

D. Latching Mechanisms: Furnish number required to hold doors in flush, smooth plane when closed.

1. For cylinder lock, furnish two keys per lock and key all locks alike.
2. For recessed panel doors, provide access sleeves for each locking device. Furnish plastic grommets and install in holes cut through finish.

E. Extruded Aluminum: After fabrication, apply manufacturer's standard protective coating on aluminum that will come in contact with concrete.

2.4 FASTENERS

A. All fasteners for all hardware shall be type 304 CRSS (18-8 series corrosion resistant stainless steel). No carbon steel or aluminum components shall be used.

2.5 HARDWARE

A. Doors shall be factory mortised and drilled for mortise template butt hinges, with #12x2” long stainless steel screws pre-installed for hinge attachment. Provide and Install hardware as listed in other section(s). If manufacturer’s standard screws do not comply, supplier shall furnish suggested screw size and type in 301CRSS (18-8 SS).

B. Frames shall be factory machined and drilled for all hardware requiring mortises, with #12x1” long stainless steel screws pre-installed for hinge attachment.

C. Hardware shall be furnished as listed in section 08710 or as so designated in appropriate section, and shall be coordinated by GC and approved by COR and installed by experienced mechanics.

D. Supplier shall furnish manufacturer’s standard templates, installation instructions, or full size approved door and frame preparation instructions as approved by the architect and as required by door and frame manufacturer prior to door and frame factory initiated manufacture. Standard factory lead-time for production of FRP doors and frames shall commence only and when all distributors required preparation information is received and acknowledged by the door and frame manufacturer.

PART 3 - EXECUTION

3.1 IDENTIFICATION

A. Factory mark all doors and frames using a chemical resistant plastic tag or indelible marker with identifying number, keyed to shop drawings, prior to shipment.

3.2 INSTALLATION

A. Comply with manufacturer's written instructions for installing access doors and frames.

B. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces.

C. Install doors flush with adjacent finish surfaces or recessed to receive finish material.

3.3 ADJUSTING AND CLEANING

A. Adjust doors and hardware after installation for proper operation.

B. Remove and replace doors and frames that are warped, bowed, or otherwise damaged.

C. Clean exposed surfaces of RFP doors and frames with a mild, non-abrasive cleaner and water.

D. Only chemical cleaning solution as recommended and available from manufacturer shall be used to assure neither finish nor door and frame properties are contaminated, nor compromised.

END OF SECTION 08 31 13

SECTION 08 41 13 - ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior storefront framing.
2. Exterior manual-swing entrance doors and door-frame units.

1.2 DEFINITIONS

A. ADA/ABA Accessibility Guidelines: U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disability Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities."

1.3 PERFORMANCE REQUIREMENTS

A. General Performance: Aluminum-framed systems shall withstand the effects of the following performance requirements without exceeding performance criteria or failure due to defective manufacture, fabrication, installation, or other defects in construction:

1. Movements of supporting structure indicated on Drawings including, but not limited to, story drift and deflection from uniformly distributed and concentrated live loads.
2. Dimensional tolerances of building frame and other adjacent construction.
3. Failure includes the following:

   a. Deflection exceeding specified limits.
   b. Thermal stresses transferring to building structure.
   c. Framing members transferring stresses, including those caused by thermal and structural movements to glazing.
   d. Glazing-to-glazing contact.
   e. Noise or vibration created by wind and by thermal and structural movements.
   f. Loosening or weakening of fasteners, attachments, and other components.
   g. Sealant failure.
   h. Failure of operating units.

B. Structural Loads:

1. Wind Loads: As indicated on Drawings.

C. Deflection of Framing Members:

1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans up to 13 feet 6 inches and to 1/240 of clear span plus 1/4 inch for spans greater than 13 feet 6 inches or an amount that restricts edge deflection of individual glazing lites to 3/4 inch, whichever is less.

2. Deflection Parallel to Glazing Plane: Limited to L/360 of clear span or 1/8 inch, whichever is smaller.

D. Structural-Test Performance: Provide aluminum-framed systems tested according to ASTM E 330 as follows:

1. When tested at positive and negative wind-load design pressures, systems do not evidence deflection exceeding specified limits.
2. When tested at 150 percent of positive and negative wind-load design pressures, systems, including anchorage, do not evidence material failures, structural distress, and permanent deformation of main framing members exceeding 0.2 percent of span.
3. Test Durations: As required by design wind velocity, as but not fewer than 10 seconds.

E. Windborne-Debris-Impact-Resistance Performance: Provide aluminum-framed systems that pass missile-impact and cyclic-pressure tests when tested according to ASTM E 1886 and testing information in ASTM E 1996 or AAMA 506.

1. Large-Missile Impact: For aluminum-framed systems located within 30 feet of grade.
2. Small-Missile Impact: For aluminum-framed systems located more than 30 feet above grade.

F. Story Drift: Provide aluminum-framed systems that accommodate design displacement of adjacent stories indicated.

1. Design Displacement: 0.0025H.
2. Test Performance: Meet criteria for passing, based on building occupancy type, when tested according to AAMA 501.4 at design displacement and 1.5 times design displacement.

G. Air Infiltration: Provide aluminum-framed systems with maximum air leakage through fixed glazing and framing areas of 0.06 cfm/sq. ft. of fixed wall area when tested according to ASTM E 283 at a minimum static-air-pressure difference of 1.57 lbf/sq. ft..

H. Water Penetration under Static Pressure: Provide aluminum-framed systems that do not evidence water penetration through fixed glazing and framing areas when tested according to ASTM E 331 at a minimum static-air-pressure difference of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft..

I. Water Penetration under Dynamic Pressure: Provide aluminum-framed systems that do not evidence water leakage through fixed glazing and framing areas when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft..

1. Maximum Water Leakage: No uncontrolled water penetrating aluminum-framed systems or water appearing on systems' normally exposed interior surfaces from sources other than condensation. Water leakage does not include water controlled by flashing and gutters that is drained to exterior and water that cannot damage adjacent materials or finishes.

J. Thermal Movements: Provide aluminum-framed systems that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures.

Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
2. Test Performance: No buckling; stress on glass; sealant failure; excess stress on framing, anchors, and fasteners; or reduction of performance when tested according to AAMA 501.5.

    a. High Exterior Ambient-Air Temperature: That which produces an exterior metal-surface temperature of 180 deg F.
    b. Low Exterior Ambient-Air Temperature: 0 deg F.

3. Interior Ambient-Air Temperature: 75 deg F.

K. Condensation Resistance: Provide aluminum-framed systems with fixed glazing and framing areas having condensation-resistance factor (CRF) of not less than 45 when tested according to AAMA 1503.

L. Thermal Conductance: Provide aluminum-framed systems with fixed glazing and framing areas having an average U-factor of not more than 0.57 Btu/sq. ft. x h x deg F when tested according to AAMA 1503.

M. Sound Transmission: Provide aluminum-framed systems with fixed glazing and framing areas having the following sound-transmission characteristics:

1. Sound Transmission Class (STC): Minimum 30 STC when tested for laboratory sound transmission loss according to ASTM E 90 and determined by ASTM E 413.
2. Outdoor-Indoor Transmission Class (OITC): Minimum 30 OITC when tested for laboratory sound transmission loss according to ASTM E 90 and determined by ASTM E 1332.

N. Structural Sealant: Capable of withstanding tensile and shear stresses imposed by aluminum-framed systems without failing adhesively or cohesively. When tested for preconstruction adhesion and compatibility, cohesive failure of sealant shall occur before adhesive failure.

1. Adhesive failure occurs when sealant pulls away from substrate cleanly, leaving no sealant material behind.
2. Cohesive failure occurs when sealant breaks or tears within itself but does not separate from each substrate because sealant-to-substrate bond strength exceeds sealant's internal strength.

O. Structural-Sealant Joints: Designed to produce tensile or shear stress of less than 20 psi.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for aluminum-framed systems.

B. Shop Drawings: For aluminum-framed systems. Include plans, elevations, sections, details, and attachments to other work.

1. Include details of provisions for system expansion and contraction and for drainage of moisture in the system to the exterior.
2. For entrance doors, include hardware schedule and indicate operating hardware types, functions, quantities, and locations.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Fabrication Sample: Of each vertical-to-horizontal intersection of aluminum-framed systems, made from 12-inch lengths of full-size components and showing details of the following:

1. Joinery, including concealed welds.
2. Anchorage.
3. Expansion provisions.
4. Glazing.
5. Flashing and drainage.

E. Other Action Submittals:

1. Entrance Door Hardware Schedule: Prepared by or under the supervision of supplier, detailing fabrication and assembly of entrance door hardware, as well as procedures and diagrams. Coordinate final entrance door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of entrance door hardware.

F. Delegated-Design Submittal: For aluminum-framed systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of aluminum-framed systems.
2. Include design calculations.

G. Qualification Data: For qualified Installer and testing agency.

H. Welding certificates.

I. Preconstruction Test Reports: For sealant.

J. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for aluminum-framed systems, indicating compliance with performance requirements.

K. Source quality-control reports.

L. Quality-Control Program for Structural-Sealant-Glazed System: Include reports.

M. Field quality-control reports.

N. Maintenance Data: For aluminum-framed systems to include in maintenance manuals.

O. Warranties: Sample of special warranties.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Testing Agency Qualifications: Qualified according to ASTM E 699 for testing indicated.

C. Engineering Responsibility: Prepare data for aluminum-framed systems, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in systems similar to those indicated for this Project.

D. Quality-Control Program for Structural-Sealant-Glazed System: Develop quality control program specifically for Project. Document quality-control procedures and verify results for aluminum-framed systems. Comply with ASTM C 1401 recommendations including, but not limited to, system material-qualification procedures, preconstruction sealant-testing program, procedures for system fabrication and installation, and intervals of reviews and checks.

E. Product Options: Information on Drawings and in Specifications establishes requirements for systems' aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods including preconstruction testing, field testing, and in-service performance.

   1. Do not revise intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If revisions are proposed, submit comprehensive explanatory data to COR for review.

F. Preconstruction Sealant Testing: For structural-sealant-glazed systems, perform sealant manufacturer's standard tests for compatibility with and adhesion of each material that will come in contact with sealants and each condition required by aluminum-framed systems.

   1. Test a minimum five samples each of metal, glazing, and other material.
   2. Prepare samples using techniques and primers required for installed systems.
   3. For materials that fail tests, determine corrective measures necessary to prepare each material to ensure compatibility with and adhesion of sealants including, but not limited to, specially formulated primers. After performing these corrective measures on the minimum number of samples required for each material, retest materials.

G. Accessible Entrances: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines.

H. Source Limitations for Aluminum-Framed Systems: Obtain from single source from single manufacturer.

I. Structural-Sealant Glazing: Comply with ASTM C 1401, "Guide for Structural Sealant Glazing" for design and installation of structural-sealant-glazed systems.

J. Structural-Sealant Joints: Design reviewed and approved by structural-sealant manufacturer.

K. Welding Qualifications: Qualify procedures and personnel according to AWS D1.2, "Structural Welding Code - Aluminum."

L. Preinstallation Conference: Conduct conference at Project site.

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of structural supports for aluminum-framed systems by field measurements before fabrication and indicate measurements on Shop Drawings.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of aluminum-framed systems that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including, but not limited to, excessive deflection.
b. Noise or vibration caused by thermal movements.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
d. Adhesive or cohesive sealant failures.
e. Water leakage through fixed glazing and framing areas.
f. Failure of operating components.

2. Warranty Period: 10 years from date of Substantial Completion.

B. Special Finish Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components on which finishes do not comply with requirements or that fail in materials or workmanship within specified warranty period. Warranty does not include normal weathering.

1. Warranty Period: 10 years from date of Substantial Completion.

1.8 MAINTENANCE SERVICE

A. Entrance Door Hardware:

1. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for FAA's continued adjustment, maintenance, and removal and replacement of entrance door hardware.
2. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of entrance door hardware Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper entrance door hardware operation at rated speed and capacity. Provide parts and supplies the same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. EFCO Corporation.
2. Kawneer North America; an Alcoa company.
3. TRACO.
4. United States Aluminum.
5. Vistawall Architectural Products; The Vistawall Group; a Bluescope Steel company.
6. YKK AP America Inc.

2.2 MATERIALS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

1. Sheet and Plate: ASTM B 209.
2. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
3. Extruded Structural Pipe and Tubes: ASTM B 429.
4. Structural Profiles: ASTM B 308/B 308M.
5. Welding Rods and Bare Electrodes: AWS A5.10/A5.10M.

B. Steel Reinforcement: Manufacturer's standard zinc-rich, corrosion-resistant primer, complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM and prepare surfaces according to applicable SSPC standard.

1. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
2. Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.
3. Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.

2.3 FRAMING SYSTEMS

A. Framing Members: Manufacturer's standard extruded-aluminum framing members of thickness required and reinforced as required to support imposed loads.

1. Construction: Thermally broken.
2. Glazing System: Retained mechanically with gaskets on four sides.
3. Glazing Plane: Front.

B. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

C. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
2. Reinforce members as required to receive fastener threads.
3. Use exposed fasteners with countersunk Phillips screw heads, finished to match framing system.

D. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts, complying with ASTM A 123/A 123M or ASTM A 153/A 153M.

E. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials.

F. Framing System Gaskets and Sealants: Manufacturer's standard, recommended by manufacturer for joint type.

1. Provide sealants for use inside of the weatherproofing system that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 ENTRANCE DOOR SYSTEMS

A. Entrance Doors: Manufacturer's entrance doors for manual-swing operation.

1. Door Construction: minimum 1-3/4-inch overall thickness, with material thickness to meet design criteria, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deeply penetrated and fillet welded or that incorporate concealed tie rods.

   a. Thermal Construction: High-performance plastic connectors separate aluminum members exposed to the exterior from members exposed to the interior.

2. Door Design: Wide stile; 5-inch nominal width.

   a. Accessible Doors: Smooth surfaced for width of door in area within 10 inches above floor or ground plane.

B. Entrance Door Hardware:

2.5 ACCESSORY MATERIALS

A. Joint Sealants: For installation at perimeter of aluminum-framed systems, as specified in Section 07 92 00 "Joint Sealants."

1. Provide sealants for use inside of the weatherproofing system that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Bituminous Paint: Cold-applied, asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos; formulated for 30-mil thickness per coat.

2.6 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Framing Members, General: Fabricate components that, when assembled, have the following characteristics:

1. Profiles that are sharp, straight, and free of defects or deformations.
2. Accurately fitted joints with ends coped or mitered.
3. Means to drain water passing joints, condensation within framing members, and moisture migrating within the system to exterior.
4. Physical and thermal isolation of glazing from framing members.
5. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
6. Provisions for field replacement of glazing from exterior.
7. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

D. Storefront Framing: Fabricate components for assembly using head-and-sill-receptor system with shear blocks at intermediate horizontal members.

E. Entrance Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.

1. At exterior doors, provide compression weather stripping at fixed stops.
2. At interior doors, provide silencers at stops to prevent metal-to-metal contact. Install three silencers on strike jamb of single-door frames and two silencers on head of frames for pairs of doors.

F. Entrance Doors: Reinforce doors as required for installing entrance door hardware.

1. At pairs of exterior doors, provide sliding-type weather stripping retained in adjustable strip and mortised into door edge.
2. At exterior doors, provide weather sweeps applied to door bottoms.

G. Entrance Door Hardware Installation: Factory install entrance door hardware to the greatest extent possible. Cut, drill, and tap for factory-installed entrance door hardware before applying finishes.

H. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.7 ALUMINUM FINISHES

A. High-Performance Organic Finish: 2-coat fluoropolymer finish complying with AAMA 2604 and containing not less than 50 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Color and Gloss: As indicated on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:

1. Comply with manufacturer's written instructions.
2. Do not install damaged components.
3. Fit joints to produce hairline joints free of burrs and distortion.
4. Rigidly secure nonmovement joints.
5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration.
6. Seal joints watertight unless otherwise indicated.

B. Metal Protection:

1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or applying sealant or tape, or by installing nonconductive spacers as recommended by manufacturer for this purpose.
2. Where aluminum will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.

D. Set continuous sill members and flashing in full sealant bed as specified in Section 07 92 00 "Joint Sealants" to produce weathertight installation.

E. Install components plumb and true in alignment with established lines and grades, and without warp or rack.

F. Install glazing as specified in Section 08 80 00 "Glazing."

G. Entrance Doors: Install doors to produce smooth operation and tight fit at contact points.

1. Exterior Doors: Install to produce weathertight enclosure and tight fit at weather stripping.

2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware according to entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.

H. Install perimeter joint sealants as specified in Section 07 92 00 "Joint Sealants" to produce weathertight installation.

3.3 ERECTION TOLERANCES

A. Install aluminum-framed systems to comply with the following maximum erection tolerances:

1. Location and Plane: Limit variation from true location and plane to 1/8 inch in 12 feet; 1/4 inch over total length.
2. Alignment:

a. Where surfaces abut in line, limit offset from true alignment to 1/16 inch.
b. Where surfaces meet at corners, limit offset from true alignment to 1/32 inch.

B. Diagonal Measurements: Limit difference between diagonal measurements to 1/8 inch.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections.

B. Testing Services: Testing and inspecting of representative areas to determine compliance of installed systems with specified requirements shall take place as follows and in successive phases as indicated on Drawings. Do not proceed with installation of the next area until test results for previously completed areas show compliance with requirements.

1. Air Infiltration: Areas shall be tested for air leakage of 1.5 times the rate specified for laboratory testing under "Performance Requirements" Article, but not more than 0.09 cfm/sq. ft., of fixed wall area when tested according to ASTM E 783 at a minimum static-air-pressure difference of 1.57 lbf/sq. ft..

C. Repair or remove work if test results and inspections indicate that it does not comply with specified requirements.

D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

E. Aluminum-framed assemblies will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust operating entrance door hardware to function smoothly as recommended by manufacturer.

1. For entrance doors accessible to people with disabilities, adjust closers to provide a 3-second closer sweep period for doors to move from a 70-degree open position to 3 inches from the latch, measured to the leading door edge. Coordinate operation with automatic operating devices.

END OF SECTION 08 41 13

SECTION 08 71 00 - DOOR HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Commercial door hardware for the following:
      a. Swinging doors.
      b. Other doors to the extent indicated.
   2. Cylinders for doors specified in other Sections.
   3. Electrified door hardware.

1.2 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

1. ASTM INTERNATIONAL (ASTM)

a.	ASTM E 283	Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
b.	ASTM F 883	Padlocks

2. BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

a.	BHMA A156.1	Butts and Hinges
b.	BHMA A156.12	Interconnected Locks & Latches
c.	BHMA A156.13	Mortise Locks & Latches, Series 1000
d.	BHMA A156.15	Closer Holder Release Devices
e.	BHMA A156.16	Auxiliary Hardware
f.	BHMA A156.17	Self Closing Hinges & Pivots
g.	BHMA A156.18	Materials and Finishes
h.	BHMA A156.2	Bored and Preassembled Locks and Latches
i.	BHMA A156.21	Thresholds
j.	BHMA A156.22	Door Gasketing and Edge Seal Systems
k.	BHMA A156.3	Exit Devices
l.	BHMA A156.4	Door Controls - Closers
m.	BHMA A156.5	Auxiliary Locks & Associated Products
n.	BHMA A156.6	Architectural Door Trim
o.	BHMA A156.7	Template Hinge Dimensions
p.	BHMA A156.8	Door Controls - Overhead Holders and Holders

3. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

   a. NFPA 101 Life Safety Code
   b. NFPA 80 Fire Doors and Fire Windows

4. STEEL DOOR INSTITUTE (SDI)

   a. SDI 100 Standard Steel Doors and Frames

5. UNDERWRITERS LABORATORIES (UL)

   a. UL Bldg Mat Dir Building Materials Directory

1.3 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 “SUBMITTAL PROCEDURES”:

1. Shop Drawings

   a. Hardware schedule;
   b. Keying system

2. Product Data

   a. Hardware items.

3. Manufacturer's Instructions

   a. Installation.

4. Operation and Maintenance Data

   a. Hardware Schedule items, Data Package 1;
   b. Submit in accordance with Section 01 78 23 “OPERATION AND MAINTENANCE DATA”.

5. Closeout Submittals

   a. Key bitting.

1.4 HARDWARE SCHEDULE

A. Prepare and submit hardware schedule in the following form:

Hardware	Quantity	Reference Publication Type Size	No.	Mfr. Name and Catalog Finish	Key Control No.	BHMA Finish Designation Listed)	UL Mark (If Fire rated and Symbols
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1.5 KEY BITTING CHART REQUIREMENTS

A. Submit key bitting charts to the Contracting Officer prior to completion of the work. Include:

1. Complete listing of all keys (AA1, AA2, etc.).
2. Complete listing of all key cuts (AA1-123456, AA2-123458).
3. Tabulation showing which key fits which door.
4. Copy of floor plan showing doors and door numbers.
5. Listing of 20 percent more key cuts than are presently required in each master system.

1.6 QUALITY ASSURANCE

A. Installer Qualifications.
1. An employer of workers trained and approved by lock manufacturer.
2. Installer's responsibilities include supplying and installing door hardware and providing a qualified Architectural Hardware Consultant available during the course of the Work to consult with Contractor, Architect, and Owner about door hardware and keying.
3. Installer shall have warehousing facilities in Project's vicinity.
4. Scheduling Responsibility: Preparation of door hardware and keying schedules.
5. Engineering Responsibility: Preparation of data for electrified door hardware, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Architectural Hardware Consultant Qualifications
1. A person who is currently certified by DHI as an Architectural Hardware Consultant and who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project.
2. Electrified Door Hardware Consultant Qualifications: A qualified Architectural Hardware Consultant who is experienced in providing consulting services for electrified door hardware installations.

C. Source Limitations
1. Obtain each type and variety of door hardware from a single manufacturer, unless otherwise indicated.
2. Provide electrified door hardware from same manufacturer as mechanical door hardware, unless otherwise indicated. Manufacturers that perform electrical modifications and that are listed by a testing and inspecting agency acceptable to authorities having jurisdiction are acceptable.

D. Fire-Rated Door Assemblies. Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 252.

E. Electrified Door Hardware. Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inventory: Inventory door hardware on receipt and provide secure lock-up for door hardware delivered to Project site.

B. Identification: Tag each item or package separately with identification related to the final door hardware sets, and include basic installation instructions, templates, and necessary fasteners with each item or package.

C. Deliver hardware in original individual containers, complete with necessary appurtenances including fasteners and instructions. Mark each individual container with item number as shown in hardware schedule. Deliver permanent keys to the Contracting Officer, either directly or by certified mail. Deliver construction master keys with the locks.

1.8 COORDINATION

A. Templates: Distribute door hardware templates for doors, frames, and other work specified to be factory prepared for installing door hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

B. Electrical System Roughing-in: Coordinate layout and installation of electrified door hardware with connections to power supplies, fire alarm system and detection devices and access control system.

C. Existing Openings: Where new hardware components are scheduled for application to existing construction or where modifications to existing door hardware are required, field verify existing conditions and coordinate installation of door hardware to suit opening conditions and to provide for proper operation.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.

B. Failures include, but are not limited to, the following:
1. Structural failures including excessive deflection, cracking, or breakage.
2. Faulty operation of operators and door hardware.
3. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

C. Warranty Period: Three years from date of Substantial Completion, except as follows:
1. Exit Devices: Two years from date of Substantial Completion.
2. Manual Closers: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SCHEDULED DOOR HARDWARE

A. General
   1. Provide door hardware for each door to comply with requirements in this Section and door hardware requirements indicated in "Door Hardware Schedule" provided on Drawings.
   2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.

B. Available Manufacturers. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 TEMPLATE HARDWARE

A. Hardware to be applied to metal or to prefinished doors shall be made to template. Promptly furnish template information or templates to door and frame manufacturers. Template hinges shall conform to BHMA A156.7. Coordinate hardware items to prevent interference with other hardware.

2.3 HARDWARE FOR FIRE DOORS AND EXIT DOORS

A. Provide all hardware necessary to meet the requirements of NFPA 80 for fire doors and NFPA 101 for exit doors, as well as to other requirements specified, even if such hardware is not specifically mentioned under paragraph entitled "Hardware Schedule." Such hardware shall bear the label of Underwriters Laboratories, Inc., and be listed in UL Bldg Mat Dir or labeled and listed by another testing laboratory acceptable to the Contracting Officer.

2.4 HARDWARE ITEMS

A. Hinges, pivots, locks, latches, exit devices, bolts, and closers shall be clearly and permanently marked with the manufacturer's name or trademark where it will be visible after the item is installed. For closers with covers, the name or trademark may be beneath the cover.

B. Hinges, general
1. Quantity: Provide the following, unless otherwise indicated:
   a. Two Hinges: For doors with heights up to 60 inches (1524 mm).
   b. Three Hinges: For doors with heights 61 to 90 inches (1549 to 2286 mm).
   c. Four Hinges: For doors with heights 91 to 120 inches (2311 to 3048 mm).
   d. For doors with heights more than 120 inches (3048 mm), provide 4 hinges, plus 1 hinge for every 30 inches (750 mm) of door height greater than 120 inches (3048 mm).
2. Hinge Weight
   a. Unless otherwise indicated, provide the following:
   b. Entrance Doors: Heavy-weight hinges.
   c. Doors with Closers: Antifriction-bearing hinges.
   d. Interior Doors: Standard-weight hinges.
3. Hinge Base Metal
   a. Unless otherwise indicated, provide the following:
   b. Exterior Hinges: Steel, with steel pin.
   c. Interior Hinges: Steel, with steel pin.
   d. Hinges for Fire-Rated Assemblies: Steel, with steel pin.
4. Hinge Options
   a. Where indicated in door hardware sets or on Drawings:
   b. Nonremovable Pins: Provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for out-swinging exterior doors and out-swinging “access control” doors.
   c. Corners: Square.
5. Fasteners
   a. Comply with the following:
   b. Machine Screws: For metal doors and frames. Install into drilled and tapped holes.
   c. Wood Screws: For wood doors and frames.
   d. Threaded-to-the-Head Wood Screws: For fire-rated wood doors.
   e. Screws: Phillips flat-head. Finish screw heads to match surface of hinges.
6. Electric Hinges. Provide electric hinges for doors with electromagnetic locks.

C. Hinges:
1. Butts and Hinges: BHMA A156.1.
2. Available Manufacturers:
   a. Hager Companies (HAG).
   b. McKinney Products Company; an ASSA ABLOY Group company (MCK).
   c. Stanley Commercial Hardware; Div. of The Stanley Works (STH).
3. Pins: Provide non-removable pins on exterior doors and all doors equipped with electromechanical locks.

Hinge Sizes Chart

Thickness of Doors in Inches	Width of Doors in Inches	Height of Hinge (Length of Joint) in Inches
7/8 to 1 1/8 screen	To 36	3
1 3/8	To 32	3 1/2
1 3/8	Over 32 to 37	4
1 3/4	To 36	4 1/2
1 3/4	Over 36 to 48	5 Heavy Weight
1 3/4	Over 48	6 Heavy Weight
2, 2 1/4 and 2 1/2	To 42	5 Heavy Weight
2, 2 1/4 and 2 1/2	Over 42	6 Heavy Weight

4. BHMA A156.1, 4 1/2 by 4 1/2 inches unless otherwise specified. Construct loose pin hinges for exterior doors and reverse-bevel interior doors so that pins will be non-removable when door is closed. Other antifriction bearing hinges may be provided in lieu of ball-bearing hinges.

D. Pivots: BHMA A156.4.

E. Spring Hinges: BHMA A156.17.

F. Locks and Latches
1. Accessibility Requirements:
   a. Where indicated to comply with accessibility requirements, comply with FED-STD-795, "Uniform Federal Accessibility Standards."
   b. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf (22 N).
2. Latches and Locks for Means of Egress Doors: Comply with NFPA 101. Latches shall not require more than 15 lbf (67 N) to release the latch. Locks shall not require use of a key, tool, or special knowledge for operation.
3. Mortise Locks and Latches: BHMA A156.13, Series 1000, Operational Grade 1, Security Grade 2. Provide mortise locks with escutcheons not less than 7 by 2 1/4 inches with a bushing at least 1/4 inch long. Cut escutcheons to suit cylinders and provide trim items with straight, beveled, or smoothly rounded sides, corners, and edges. Knobs and roses of mortise locks shall have screwless shanks and no exposed screws.
4. Bored Locks and Latches: BHMA A156.2, Series 4000, Grade 1.
5. Electrified Locking Devices: BHMA A156.25.
6. Auxiliary Locks: BHMA A156.5, Grade 1.
7. Lock Trim: Cast, forged, or heavy wrought construction and commercial plain design.
   a. Knobs and Roses: In addition to meeting test requirements of BHMA A156.2 and BHMA A156.13, knobs, roses, and escutcheons shall be 0.050 inch thick if unreinforced. If reinforced, outer shell shall be 0.035 inch thick and combined thickness shall be 0.070 inch, except knob shanks shall be 0.060 inch thick.
   b. Lever Handles: Provide lever handles. Lever handles for exit devices shall meet the test requirements of BHMA A156.13 for mortise locks. Lever handle locks shall have a breakaway feature such as a weakened spindle or a shear key to prevent irreparable damage to the lock when a force in excess of that specified in

BHMA A156.13 is applied to the lever handle. Lever handles shall return to within 1/2 inch of the door face.

c. Texture: Provide knurled or abrasive coated knobs or lever handles for doors which are accessible to blind persons and which lead to dangerous areas.

8. Lock Throw
   a. Comply with testing requirements for length of bolts required for labeled fire doors, and as follows:
   b. Mortise Locks: Minimum 3/4-inch (19-mm) latchbolt throw.
9. Strikes:
   a. Manufacturer's standard strike with strike box for each latchbolt or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, and as follows:
   b. Strikes for Mortise Locks and Latches: BHMA A156.13.

G. Door Bolts
1. Bolt Throw
   a. Comply with testing requirements for length of bolts required for labeled fire doors, and as follows:
   b. Mortise Flush Bolts: Minimum 3/4-inch (19-mm) throw.
2. Dustproof Strikes: BHMA A156.16, Grade 1; provide dustproof strikes for bottom bolts, except for doors having metal thresholds.
3. Manual Flush Bolts:
   BHMA A156.16, Grade 1 unless Grade 2 is indicated; designed for mortising into door edge.
   a. Available Manufacturers:
      1) Glynn-Johnson; an Ingersoll-Rand Company (GJ).
      2) IVES Hardware; an Ingersoll-Rand Company (IVS).]
      3) Trimco (TR).
      4) McKinney
      5) Rockwood

H. Electromechanical Locks
1. General. Grade 1 unless Grade 2 is indicated for type of lock indicated; motor or solenoid driven.
2. Available Manufacturer:
   a. Best Access Systems; Div. of The Stanley Works (BAS).

I. Exit Devices
1. Exit Devices General: BHMA A156.3, Grade 1unless Grade 2 is indicated. Provide adjustable strikes for rim type and vertical rod devices. Provide open back strikes for pairs of doors with mortise and vertical rod devices. Touch bars shall be provided in lieu of conventional crossbars and arms.
2. Accessibility Requirements:
   a. Where handles, pulls, latches, locks, and other operating devices are indicated to comply with accessibility requirements, comply with FED-STD-795, "Uniform Federal Accessibility Standards."
   b. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf (22 N).

3. Exit Devices for Means of Egress Doors: Comply with NFPA 101. Exit devices shall not require more than 15 lbf (67 N) to release the latch. Locks shall not require use of a key, tool, or special knowledge for operation.
4. Panic Exit Devices. Listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for panic protection, based on testing according to UL 305.
5. Fire Exit Devices. Devices complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire and panic protection, based on testing according to UL 305 and NFPA 252.
6. Outside Trim
    a. Match design for locksets and latchsets, unless otherwise indicated.
7. Available Manufacturers:
    a. Sargent Manufacturing
    b. Precision Hardware, Inc. (PH).
    c. Von Duprin; an Ingersoll-Rand Company (VD).
    d. Corbin Russwin
    e. Yale

J. Lock Cylinders
1. Standard Lock Cylinders: Best.
2. Cylinders
    a. Manufacturer's standard tumbler type, constructed from brass or bronze, stainless steel, or nickel silver, and complying with the following:
    b. Number of Pins: Seven.
    c. Mortise Type: Threaded cylinders with rings and straight- or clover-type cam.
    d. Rim Type: Cylinders with back plate, flat-type vertical or horizontal tailpiece, and raised trim ring.
    e. Bored-Lock Type: Cylinders with tailpieces to suit locks.
3. Permanent Cores
    a. Manufacturer's standard; finish face to match lockset; complying with the following:
    b. Removable Cores: Core insert, removable by use of a special key; for use only with core manufacturer's cylinder and door hardware.
4. Construction Keying. Comply with the following:
    a. Construction Cores: Provide construction cores that are replaceable by permanent cores. Provide 10 construction master keys.
    b. Furnish permanent cores to Owner for installation.
5. Manufacturer. Same manufacturer as for locks and latches.

K. Keying
1. Keying System
    a. Factory registered, complying with guidelines in BHMA A156.28, Appendix A. Incorporate decisions made in keying conference, and as follows:
    b. Grand Master Key System: Cylinders are operated by a change key, a master key, and a grand master key.
2. Keys
    a. Nickel silver.
    b. Stamping: Permanently inscribe each key with a visual key control number and include the following notation: "DO NOT DUPLICATE."
    c. Quantity: In addition to one extra key blank for each lock, provide the following:

d. Cylinder Change Keys: Three.
e. Master Keys: Five.
f. Grand Master Keys: Five.
g. Great-Grand Master Keys: Five.

L. Key Cabinet and Control System
1. Key Control Cabinet
a. BHMA A156.5, Grade 1; metal cabinet with baked-enamel finish; containing key-holding hooks, labels, 2 sets of key tags with self-locking key holders, key-gathering envelopes, and temporary and permanent markers; with key capacity of 150 percent of the number of locks.
b. Wall-Mounted Cabinet: Cabinet with hinged-panel door equipped with key-holding panels and pin-tumbler cylinder door lock.
2. Location: Mount the key control cabinet as directed by the FAA RE in the field.

M. Auxiliary Door Hardware
1. Door Protection Plates: BHMA A156.6.

a. Sizes of Mop and Kick Plates: Width for single doors shall be 2 inches less than door width; width for pairs of doors shall be one inch less than door width. Height of kick plates shall be 10 inches for flush doors and one inch less than height of bottom rail for panel doors. Height of mop plates shall be 6 inches.

N. Closers
1. Accessibility Requirements:
a. Where handles, pulls, latches, locks, and other operating devices are indicated to comply with accessibility requirements, comply with FED-STD-795, "Uniform Federal Accessibility Standards."
b. Comply with the following maximum opening-force requirements:
c. Interior, Non-Fire-Rated Hinged Doors: 5 lbf (22.2 N) applied perpendicular to door.
d. Fire Doors: Minimum opening force allowable by authorities having jurisdiction.
2. Door Closers for Means of Egress Doors: Comply with NFPA 101. Door closers shall not require more than 30 lbf (133 N) to set door in motion and not more than 15 lbf (67 N) to open door to minimum required width.
3. Flush Floor Plates: Provide finish cover plates for floor closers unless thresholds are indicated. Match door hardware finish, unless otherwise indicated.
4. Size of Units: Unless otherwise indicated, comply with manufacturer's written recommendations for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.
5. Surface Closers: BHMA A156.4, Grade 1 unless Grade 2 is indicated. Provide type of arm required for closer to be located on non-public side of door, unless otherwise indicated.
6. Available Manufacturers:
a. LCN Closers; an Ingersoll-Rand Company (LCN).
b. Norton Door Controls; an ASSA ABLOY Group company (NDC).
c. Sargent Manufacturing

O. Stops and Holders
1. Stops and Bumpers:
a. BHMA A156.16, Grade 1 unless Grade 2 is indicated.
b. Provide floor stops for doors unless wall or other type stops are scheduled or indicated. Do not mount floor stops where they will impede traffic. Where floor or wall stops are not appropriate, provide overhead holders.
2. Available Manufacturers:
a. Glynn-Johnson; an Ingersoll-Rand Company (GJ).
b. Trimco (TR).
c. McKinney
d. Rockwood
3. Door Silencers: BHMA A156.16. Silencers Type L03011. Provide three silencers for each single door, two for each pair.
4. Overhead Holders: BHMA A156.8.
5. Closer Holder-Release Devices: BHMA A156.15.

P. Thresholds
1. Standard. BHMA A156.21. Listed under Category J in BHMA's "Certified Product Directory."
2. Accessibility Requirements:
a. Where thresholds are indicated to comply with accessibility requirements, comply with FED-STD-795, "Uniform Federal Accessibility Standards."
b. Bevel raised thresholds with a slope of not more than 1:2. For the Base Building, provide thresholds not more than 1/2 inch (13 mm) high.
3. Thresholds for Means of Egress Doors. Comply with NFPA 101. Maximum 1/2 inch (13 mm) high.
4. Available Manufacturers:
a. Pemko Manufacturing Co. (PEM).
b. Reese Enterprises (RE).
c. Zero International (ZRO).
d. McKinney

Q. Door Gasketing
1. Standard. BHMA A156.22. Listed under Category J in BHMA's "Certified Product Directory."
2. General
a. Provide continuous weather-strip gasketing on exterior doors and provide smoke, light, or sound gasketing on interior doors where indicated or scheduled. Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.
b. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.
c. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.
d. Air Leakage: Not to exceed 0.50 cfm per foot (0.000774 cu. m/s per m) of crack length for gasketing other than for smoke control, as tested according to ASTM E 283.
e. Smoke-Labeled Gasketing:
1) Assemblies complying with NFPA 105 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for smoke-control ratings indicated, based on testing according to UL 1784.

2) Provide smoke-labeled gasketing on 20-minute-rated doors and on smoke-labeled doors.

f. Fire-Labeled Gasketing:
   1) Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 252.
   2) Test Pressure: After 5 minutes into the test, neutral pressure level in furnace shall be established at 40 inches (1016 mm) or less above the sill.

g. Sound-Rated Gasketing: Assemblies that are listed and labeled by a testing and inspecting agency, for sound ratings indicated, based on testing according to ASTM E 1408.

h. Replaceable Seal Strips: Provide only those units where resilient or flexible seal strips are easily replaceable and readily available from stocks maintained by manufacturer.

i. Gasketing Materials: ASTM D 2000 and AAMA 701/702.

j. Available Manufacturers:
   1) Pemko Manufacturing Co. (PEM).
   2) Reese Enterprises (RE).
   3) Zero International (ZRO).
   4) McKinney

R. Rain Drips: Extruded aluminum, not less than 0.08 inch thick, bronze anodized. Set drips in sealant conforming to Section 07 92 00 “JOINT SEALANTS” and fasten with stainless steel screws.
   a. Door Rain Drips: Approximately 1 1/2 inches high by 5/8 inch projection. Align bottom with bottom edge of door.
   b. Overhead Rain Drips: Approximately 1 1/2 inches high by 2 1/2 inches projection, with length equal to overall width of door frame. Align bottom with door frame rabbet.

S. Special Tools: Provide special tools, such as spanner and socket wrenches and dogging keys, required to service and adjust hardware items.

T. Miscellaneous Door Hardware:
   1. Boxed Power Supplies: Modular unit in NEMA ICS 6, Type 4 enclosure; filtered and regulated; voltage rating and type matching requirements of door hardware served; and listed and labeled for use with fire alarm systems.

2.5 FASTENERS

A. Provide fasteners of proper type, quality, size, quantity, and finish with hardware. Fasteners exposed to weather shall be of nonferrous metal or stainless steel. Provide fasteners of type necessary to accomplish a permanent installation.

2.6 FABRICATION

A. Manufacturer's Nameplate:
   1. Do not provide products that have manufacturer's name or trade name displayed in a visible location except in conjunction with required fire-rated labels and as otherwise approved by Architect.

2. Manufacturer's identification is permitted on rim of lock cylinders only.

B. Base Metals: Produce door hardware units of base metal, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18. Do not furnish manufacturer's standard materials or forming methods if different from specified standard.

C. Fasteners:
   1. Provide door hardware manufactured to comply with published templates generally prepared for machine, wood, and sheet metal screws. Provide screws according to commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.
   2. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.
   3. Steel Machine or Wood Screws: For the following fire-rated applications:
      a. Mortise hinges to doors.
      b. Strike plates to frames.
      c. Closers to doors and frames.
   4. Steel Through Bolts: For the following fire-rated applications unless door blocking is provided:
      a. Surface hinges to doors.
      b. Closers to doors and frames.
      c. Surface-mounted exit devices.
   5. Spacers or Sex Bolts: For through bolting of hollow-metal doors.
   6. Fasteners for Wood Doors: Comply with requirements in DHI WDHS.2, "Recommended Fasteners for Wood Doors."

2.7 FINISHES

A. BHMA A156.18. Hardware shall have BHMA 630 finish (satin stainless steel), unless specified otherwise. Provide items not manufactured in stainless steel in BHMA 626 finish (satin chromium plated) over brass or bronze, except surface door closers which shall have aluminum paint finish, and except steel hinges which shall have BHMA 652 finish (satin chromium plated). Hinges for exterior doors shall be stainless steel with BHMA 630 finish or chromium plated brass or bronze with BHMA 626 finish. Exit devices may be provided in BHMA 626 finish in lieu of BHMA 630 finish. Exposed parts of concealed closers shall have finish to match lock and door trim. Hardware for aluminum doors shall be finished to match the doors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Doors and Frames. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.

B. Roughing In. Examine roughing-in for electrical power systems to verify actual locations of wiring connections before electrified door hardware installation.

C. Installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Steel Doors and Frames
1. Comply with DHI A115 Series.
2. Surface-Applied Door Hardware: Drill and tap doors and frames according to ANSI A250.6.

B. Wood Doors. Comply with DHI A115-W Series.

3.3 INSTALLATION

A. Mounting Heights
1. Mount door hardware units at heights indicated unless otherwise indicated or required to comply with governing regulations.
2. Standard Steel Doors and Frames: DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
3. Wood Doors: DHI WDHS.3, "Recommended Locations for Architectural Hardware for Wood Flush Doors."

B. Installation
1. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 9 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.
2. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
3. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.

C. Key Control System. Tag keys and place them on markers and hooks in key control system cabinet, as determined by final keying schedule.

D. Boxed Power Supplies.

1. Locate power supplies as indicated or, if not indicated, in equipment room. Verify location with Resident Engineer.
2. Configuration: Provide one power supply for each door opening.
3. Configuration: Provide the least number of power supplies required to adequately serve doors with electrified door hardware.

E. Thresholds. Set thresholds for exterior and acoustical doors in full bed of sealant complying with requirements specified in Division 7 Section "Joint Sealants."

3.4 ADJUSTING

A. Initial Adjustment
   1. Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
   2. Door Closers: Unless otherwise required by authorities having jurisdiction, adjust sweep period so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches (75 mm) from the latch, measured to the leading edge of the door.

B. Occupancy Adjustment. Examine and readjust, including adjusting operating forces, each item of door hardware as necessary to ensure function of doors, door hardware, and electrified door hardware.

3.5 CLEANING AND PROTECTION

A. Adjacent Surfaces. Clean adjacent surfaces soiled by door hardware installation.

B. Operating Items. Clean operating items as necessary to restore proper function and finish.

C. Substantial Completion. Provide final protection and maintain conditions that ensure that door hardware is without damage or deterioration at time of Substantial Completion.

3.6 DEMONSTRATION

A. Training. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain door hardware and door hardware finishes. Refer to Division 1 Section "Demonstration and Training."

3.7 HARDWARE SETS

A. Hardware for aluminum doors shall be provided under this section. Deliver Hardware templates and hardware, except field-applied hardware to the aluminum door and frame manufacturer for use in fabricating the doors and frames.

END OF SECTION 08 71 00

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SECTION 08 83 00 - MIRRORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of silvered flat glass mirrors:

1. Annealed monolithic glass mirrors.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Mirrors. Include description of materials and process used to produce each type of silvered flat glass mirror specified that indicates sources of glass, glass coating components, edge sealer, and quality-control provisions.

B. Shop Drawings: Include mirror elevations, edge details, mirror hardware, and attachments to other work.

C. Samples: For each type of the following products:

1. Mirrors: 12 inches square, including edge treatment on two adjoining edges.
2. Mirror Clips: Full size.
3. Mirror Trim: 12 inches long.

D. Product Certificates: For each type of mirror, from manufacturer.

E. Preconstruction Test Reports: From mirror manufacturer indicating that mirror mastic was tested for compatibility and adhesion with mirror backing film and substrates on which mirrors are installed.

F. Maintenance Data: For mirrors to include in maintenance manuals.

G. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs glass installers for this Project who are certified under the National Glass Association's Certified Glass Installer Program.

B. Source Limitations for Mirrors: Obtain mirrors from single source from single manufacturer.

C. Source Limitations for Mirror Accessories: Obtain mirror glazing accessories from single source.

D. Glazing Publications: Comply with the following published recommendations:

1. GANA's "Glazing Manual" unless more stringent requirements are indicated. Refer to this publication for definitions of glass and glazing terms not otherwise defined in this Section or in referenced standards.
2. GANA Mirror Division's "Mirrors, Handle with Extreme Care: Tips for the Professional on the Care and Handling of Mirrors."

E. Safety Glazing Products: For mirrors, provide products complying with testing requirements in 16 CFR 1201 for Category II materials.

F. Preconstruction Mirror Mastic Compatibility Test: Submit mirror mastic products to mirror manufacturer for testing to determine compatibility of mastic with mirror backing film and substrates on which mirrors are installed.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect mirrors according to mirror manufacturer's written instructions and as needed to prevent damage to mirrors from moisture, condensation, temperature changes, direct exposure to sun, or other causes.

B. Comply with mirror manufacturer's written instructions for shipping, storing, and handling mirrors as needed to prevent deterioration of silvering, damage to edges, and abrasion of glass surfaces and applied coatings. Store indoors.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not install mirrors until ambient temperature and humidity conditions are maintained at levels indicated for final occupancy.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which mirror manufacturer agrees to replace mirrors that deteriorate within specified warranty period. Deterioration of mirrors is defined as defects developed from normal use that are not attributed to mirror breakage or to maintaining and cleaning mirrors contrary to manufacturer's written instructions. Defects include discoloration, black spots, and clouding of the silver film.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SILVERED FLAT GLASS MIRRORS

A. Glass Mirrors, General: ASTM C 1503

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Arch Aluminum & Glass Co., Inc.
   b. Avalon Glass and Mirror Company.
   c. Binswanger Mirror; a division of Vitro America, Inc.
   d. D & W Incorporated
   e. Donisi Mirror Company.
   f. Gardner Glass, Inc.
   g. Gilded Mirrors, Inc.
   h. Guardian Industries.
   i. Head West.
   j. Independent Mirror Industries, Inc.
   k. Lenoir Mirror Company.
   l. Maran-Wurzell Glass & Mirror.
   m. National Glass Industries.
   n. Stroupe Mirror Co., Inc.
   o. Sunshine Mirror; Westshore Glass Corp.
   p. Virginia Mirror Company, Inc.
   q. Walker Glass Co., Ltd.
   r. Washroom Equipment
   s. Bobrick, Inc.
   t. Bradley Corporation

2.2 MISCELLANEOUS MATERIALS

A. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.

B. Edge Sealer: Coating compatible with glass coating and approved by mirror manufacturer for use in protecting against silver deterioration at mirrored glass edges.

C. Mirror Mastic: An adhesive setting compound, asbestos-free, produced specifically for setting mirrors and certified by both mirror manufacturer and mastic manufacturer as compatible with glass coating and substrates on which mirrors will be installed.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Franklin International; Titebond Division.
   b. Laurence, C. R. Co., Inc.
   c. Macco Adhesives; Liquid Nails Division.
   d. OSI Sealants, Inc.
   e. Palmer Products Corporation.
   f. Pecora Corporation.
   g. Royal Adhesives & Sealants; Gunther Mirror Mastics Division.
   h. Sommer & Maca Industries, Inc.

D. Film Backing for Safety Mirrors: Film backing and pressure-sensitive adhesive; both compatible with mirror backing paint as certified by mirror manufacturer.

2.3 MIRROR HARDWARE

A. Top and Bottom Aluminum J-Channels: Aluminum extrusions with a return deep enough to produce a glazing channel to accommodate mirrors of thickness indicated and in lengths required to cover bottom and top edges of each mirror in a single piece.

1. Bottom Trim: J-channels formed with front leg and back leg not less than 3/8 and 7/8 inch in height, respectively, and a thickness of not less than 0.04 inch .

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) Laurence, C. R. Co., Inc.; CRL Standard "J" Channel.
        2) Sommer & Maca Industries, Inc.; Aluminum Shallow Nose "J" Moulding Lower Bar.
        3) Sommer & Maca Industries, Inc.; Heavy Gauge Aluminum Shallow Nose "J" Moulding Lower Bar.

2. Top Trim: J-channels formed with front leg and back leg not less than 5/8 and 1 inch in height, respectively, and a thickness of not less than 0.04 inch .

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) Laurence, C. R. Co., Inc.; CRL Deep "J" Channel.
        2) Sommer & Maca Industries, Inc.; Aluminum Deep Nose "J" Moulding Upper Bar.
        3) Sommer & Maca Industries, Inc.; Heavy Gauge Aluminum Deep Nose "J" Moulding Lower Bar.

3. Finish: Clear bright anodized.

2.4 FABRICATION

A. Mirror Sizes: To suit Project conditions, cut mirrors to final sizes and shapes.

B. Mirror Edge Treatment: Flat polished.

1. Seal edges of mirrors with edge sealer after edge treatment to prevent chemical or atmospheric penetration of glass coating.
2. Require mirror manufacturer to perform edge treatment and sealing in factory immediately after cutting to final sizes.

C. Film-Backed Safety Mirrors: Apply film backing with adhesive coating over mirror backing paint as recommended in writing by film-backing manufacturer to produce a surface free of bubbles, blisters, and other imperfections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, over which mirrors are to be mounted, with Installer present, for compliance with installation tolerances, substrate preparation, and other conditions affecting performance of the Work.

B. Verify compatibility with and suitability of substrates, including compatibility of mirror mastic with existing finishes or primers.

C. Proceed with installation only after unsatisfactory conditions have been corrected and surfaces are dry.

3.2 PREPARATION

A. Comply with mastic manufacturer's written installation instructions for preparation of substrates, including coating substrates with mastic manufacturer's special bond coating where applicable.

3.3 INSTALLATION

A. General: Install mirrors to comply with mirror manufacturer's written instructions and with referenced GANA publications. Mount mirrors accurately in place in a manner that avoids distorting reflected images.

B. Provide a minimum air space of 1/8 inch between back of mirrors and mounting surface for air circulation between back of mirrors and face of mounting surface.

C. Wall-Mounted Mirrors: Install mirrors with mastic and mirror hardware. Attach mirror hardware securely to mounting surfaces with mechanical fasteners installed with anchors or inserts as applicable. Install fasteners so heads do not impose point loads on backs of mirrors.

1. Top and Bottom Aluminum J-Channels: Provide setting blocks 1/8 inch thick by 4 inches long at quarter points. To prevent trapping water, provide, between setting blocks, two slotted weeps not less than 1/4 inch wide by 3/8 inch long at bottom channel.
2. Top Channel/Cleat and Bottom Aluminum J-Channels: Fasten J-channel directly to wall and attach top trim to continuous cleat fastened directly to wall.
3. Mirror Clips: Place a felt or plastic pad between mirror and each clip to prevent spalling of mirror edges. Locate clips where indicated
4. Install mastic as follows:

    a. Apply barrier coat to mirror backing where approved in writing by manufacturers of mirrors and backing material.
    b. Apply mastic to comply with mastic manufacturer's written instructions for coverage and to allow air circulation between back of mirrors and face of mounting surface.

c. After mastic is applied, align mirrors and press into place while maintaining a minimum air space of 1/8 inch between back of mirrors and mounting surface.

3.4 CLEANING AND PROTECTION

A. Protect mirrors from breakage and contaminating substances resulting from construction operations.

B. Do not permit edges of mirrors to be exposed to standing water.

C. Maintain environmental conditions that will prevent mirrors from being exposed to moisture from condensation or other sources for continuous periods of time.

D. Wash exposed surface of mirrors not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash mirrors as recommended in writing by mirror manufacturer.

END OF SECTION 08 83 00

SECTION 09 22 16 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes non-load-bearing steel framing members for the following applications:

1. Interior and exterior framing systems (e.g., supports for partition walls, framed soffits, furring, etc.).

B. Interior suspension systems (e.g., supports for ceilings, suspended soffits, etc.).

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

PART 2 - PRODUCTS

2.1 NON-LOAD-BEARING STEEL FRAMING, GENERAL

A. Framing Members, General: Comply with ASTM C 754 for conditions indicated.

1. Steel Sheet Components: Comply with ASTM C 645 requirements for metal, unless otherwise indicated.
2. Protective Coating: ASTM A 653/A 653M, G60 hot-dip galvanized, unless otherwise indicated.

2.2 SUSPENSION SYSTEM COMPONENTS

A. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.0625-inch- diameter wire, or double strand of 0.0475-inch- diameter wire.

B. Hanger Attachments to Concrete:

1. Powder-Actuated Fasteners: Suitable for application indicated, fabricated from corrosion-resistant materials with clips or other devices for attaching hangers of type indicated, and capable of sustaining, without failure, a load equal to 10 times that imposed by construction as determined by testing according to ASTM E 1190 by an independent testing agency.

C. Wire Hangers: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.162-inch diameter.

D. Carrying Channels: Cold-rolled, commercial-steel sheet with a base-metal thickness of 0.0538 inch and minimum 1/2-inch- wide flanges.

1. Depth: As indicated on Drawings

E. Furring Channels (Furring Members):

1. Hat-Shaped, Rigid Furring Channels: ASTM C 645, 7/8 inch deep.

a. Minimum Base Metal Thickness: 0.0179 inch.

F. Grid Suspension System for Ceilings: ASTM C 645, direct-hung system composed of main beams and cross-furring members that interlock.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Armstrong World Industries, Inc.; Drywall Grid Systems.
b. Chicago Metallic Corporation; 640-C Drywall Furring System.
c. USG Corporation; Drywall Suspension System.

2.3 STEEL FRAMING FOR FRAMED ASSEMBLIES

A. Steel Studs and Runners: ASTM C 645.

1. Minimum Base-Metal Thickness: 0.0179 inch. 0.0346 inch min. thickness (20 ga. Structural stud) supporting wall hung items such as cabinetry, equipment, and fixtures, unless indicated otherwise on drawings.
2. Depth: As indicated on Drawings

B. Slip-Type Head Joints: Where indicated, provide one of the following:

1. Single Long-Leg Runner System: ASTM C 645 top runner with 2-inch- deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top runner and with continuous bridging located within 12 inches of the top of studs to provide lateral bracing.
2. Double-Runner System: ASTM C 645 top runners, inside runner with 2-inch- deep flanges in thickness not less than indicated for studs and fastened to studs, and outer runner sized to friction fit inside runner.
3. Deflection Track: Steel sheet top runner manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.

a. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
b. Products: Subject to compliance with requirements, provide one of the following:

1) Steel Network Inc. (The); VertiClip SLD VertiTrack VTD Series.
2) Superior Metal Trim; Superior Flex Track System (SFT).

C. Firestop Tracks: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Fire Trak Corp.; Fire Trak attached to studs with Fire Trak Slip Clip.
b. Metal-Lite, Inc.; The System.

D. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.

1. Minimum Base-Metal Thickness: 0.0179 inch

E. Cold-Rolled Channel Bridging: 0.0538-inch bare-steel thickness, with minimum 1/2-inch- wide flanges.

1. Depth: As indicated on Drawings
2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches, 0.068-inch- thick, galvanized steel.

F. Hat-Shaped, Rigid Furring Channels: ASTM C 645.

1. Minimum Base Metal Thickness: 0.0179 inch
2. Depth: As indicated on Drawings

G. Resilient Furring Channels: 1/2-inch- deep, steel sheet members designed to reduce sound transmission.

H. Cold-Rolled Furring Channels: 0.0538-inch bare-steel thickness, with minimum 1/2-inch- wide flanges.

1. Depth: As indicated on Drawings
2. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with minimum bare-steel thickness of 0.0312 inch.
3. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.0625-inch-diameter wire, or double strand of 0.0475-inch- diameter wire.

I. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches, wall attachment flange of 7/8 inch, minimum bare-metal thickness of 0.0179 inch, and depth required to fit insulation thickness indicated.

2.4 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards.

1. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

B. Isolation Strip at Exterior Walls: Provide one of the following:

1. Asphalt-Saturated Organic Felt: ASTM D 226, Type I (No. 15 asphalt felt), nonperforated.
2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.

1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.

B. Coordination with Sprayed Fire-Resistive Materials:

1. Before sprayed fire-resistive materials are applied, attach offset anchor plates or ceiling runners (tracks) to surfaces indicated to receive sprayed fire-resistive materials. Where offset anchor plates are required, provide continuous plates fastened to building structure not more than 24 inches o.c.
2. After sprayed fire-resistive materials are applied, remove them only to extent necessary for installation of non-load-bearing steel framing. Do not reduce thickness of fire-resistive materials below that required for fire-resistance ratings indicated. Protect adjacent fire-resistive materials from damage.

3.3 INSTALLATION, GENERAL

A. Installation Standard: ASTM C 754, except comply with framing sizes and spacing indicated.

   1. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.

B. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.

C. Install bracing at terminations in assemblies.

D. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.4 INSTALLING SUSPENSION SYSTEMS

A. Install suspension system components in sizes and spacings indicated on Drawings, but not less than those required by referenced installation standards for assembly types and other assembly components indicated.

B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

C. Suspend hangers from building structure as follows:

   1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.

      a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

   2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

      a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.

   3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.
   4. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
   5. Do not attach hangers to steel roof deck.
   6. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.

7. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
8. Do not connect or suspend steel framing from ducts, pipes, or conduit.

D. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.

E. Grid Suspension Systems: Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

F. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

3.5 INSTALLING FRAMED ASSEMBLIES

A. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

B. Install studs so flanges within framing system point in same direction.

1. Space studs as follows:

a. Single-Layer Application: 16 inches o.c., unless otherwise indicated.
b. Multilayer Application: 16 inches o.c., unless otherwise indicated.
c. Tile backing panels: 16 inches o.c., unless otherwise indicated.

C. Install tracks (runners) at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts penetrating partitions above ceiling.

1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.

a. Install two studs at each jamb, unless otherwise indicated.
b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch clearance from jamb stud to allow for installation of control joint in finished assembly.
c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.

3. Other Framed Openings: Frame openings other than door openings the same as required for door openings, unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.

a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.

5. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.
6. Curved Partitions:

   a. Bend track to uniform curve and locate straight lengths so they are tangent to arcs.
   b. Begin and end each arc with a stud, and space intermediate studs equally along arcs. On straight lengths of not less than 2 studs at ends of arcs, place studs 6 inches o.c.

D. Direct Furring:

1. Screw to wood framing.
2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.

E. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.

END OF SECTION 09 22 16

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SECTION 09 29 00 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Interior gypsum board.
2. Exterior gypsum board for ceilings and soffits.
3. Tile backing panels.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For the following products:

1. Trim Accessories: Full-size Sample in 12-inch- long length for each trim accessory indicated.
2. Textured Finishes: Manufacturer's standard size for each textured finish indicated and on same backing indicated for Work.

1.3 QUALITY ASSURANCE

A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

1.4 STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against damage from weather, condensation, direct sunlight, construction traffic, and other causes. Stack panels flat to prevent sagging.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.

B. Do not install interior products until installation areas are enclosed and conditioned.

C. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PANELS, GENERAL

A. Size: Provide in maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.2 INTERIOR GYPSUM BOARD

A. General: Complying with ASTM C 36/C 36M or ASTM C 1396/C 1396M, as applicable to type of gypsum board indicated and whichever is more stringent.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Gypsum Co.
b. BPB America Inc.
c. G-P Gypsum.
d. Lafarge North America Inc.
e. National Gypsum Company.
f. PABCO Gypsum.
g. Temple.
h. USG Corporation.

B. Regular Type:

1. Thickness: Minimum 5/8 inch, or as required by fire-resistance-rated assembly indicated on drawings.
2. Long Edges: Tapered

C. Type X:

1. Thickness: 5/8 inch.
2. Long Edges: Tapered.

D. Type C:

1. Thickness: As required by fire-resistance-rated assembly indicated on Drawings.
2. Long Edges: Tapered.

E. Ceiling Type: Manufactured to have more sag resistance than regular-type gypsum board.

1. Thickness: 5/8 inch.
2. Long Edges: Tapered.

F. Abuse-Resistant Type: Manufactured to produce greater resistance to surface indentation, through-penetration (impact resistance), and abrasion than standard, regular-type and Type X gypsum board.

1. Core: As indicated on Drawings.
2. Long Edges: Tapered.

G. Moisture- and Mold-Resistant Type: With moisture- and mold-resistant core and surfaces.

1. Core: 5/8 inch, Type X.
2. Long Edges: Tapered.

H. Sound Attenuating Gypsum Board

1. Core: As indicated on drawings
2. Long Edges: Tapered

2.3 EXTERIOR GYPSUM BOARD FOR CEILINGS AND SOFFITS

A. Exterior Gypsum Soffit Board: ASTM C 931/C 931M or ASTM C 1396/C 1396M, with manufacturer's standard edges.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Gypsum Co.
b. BPB America Inc.
c. G-P Gypsum.
d. Lafarge North America Inc.
e. National Gypsum Company.
f. PABCO Gypsum.
g. Temple.
h. USG Corporation.

2. Core: As indicated

B. Glass-Mat Gypsum Sheathing Board: ASTM C 1177/C 1177M.

1. Product: Subject to compliance with requirements, provide "Dens-Glass Gold" by G-P Gypsum.
2. Core: As indicated

2.4 TILE BACKING PANELS

A. Cementitious Backer Units: ANSI A118.9.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

   a. Custom Building Products; Wonderboard.
   b. FinPan, Inc.; Util-A-Crete Concrete Backer Board.
   c. USG Corporation; DUROCK Cement Board.

2. Thickness: As indicated on Drawings

2.5 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Material: Galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized steel sheet.
2. Shapes:

   a. Cornerbead.
   b. Bullnose bead.
   c. LC-Bead: J-shaped; exposed long flange receives joint compound.
   d. L-Bead: L-shaped; exposed long flange receives joint compound.
   e. U-Bead: J-shaped; exposed short flange does not receive joint compound.
   f. Expansion (control) joint.
   g. Curved-Edge Cornerbead: With notched or flexible flanges.

B. Exterior Trim: ASTM C 1047.

1. Material: Hot-dip galvanized steel sheet, plastic, or rolled zinc.
2. Shapes:

   a. Cornerbead.
   b. LC-Bead: J-shaped; exposed long flange receives joint compound.
   c. Expansion (Control) Joint: One-piece, rolled zinc with V-shaped slot and removable strip covering slot opening.

C. Aluminum Trim: Extruded accessories of profiles and dimensions indicated.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Fry Reglet Corp.
   b. Gordon, Inc.
   c. Pittcon Industries.

2. Aluminum: Alloy and temper with not less than the strength and durability properties of ASTM B 221, Alloy 6063-T5.
3. Finish: Corrosion-resistant primer compatible with joint compound and finish materials specified.

2.6 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475/C 475M.

B. Joint Tape:

1. Interior Gypsum Wallboard: Paper, or as recommended by manufacturer
2. Exterior Gypsum Soffit Board: Paper, or as recommended by manufacturer
3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
4. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.

   a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use setting-type, sandable topping compound.
4. Finish Coat: For third coat, use setting-type, sandable topping
5. Skim Coat: For final coat of Level 5 finish, use setting-type, sandable topping compound

D. Joint Compound for Exterior Applications:

1. Exterior Gypsum Soffit Board: Use setting-type taping compound and setting-type, sandable topping compound.
2. Glass-Mat Gypsum Sheathing Board: As recommended by sheathing board manufacturer.

E. Joint Compound for Tile Backing Panels:

1. Cementitious Backer Units: As recommended by backer unit manufacturer.

2.7 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.

B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

C. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.

1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.
2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

D. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.

1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

E. Acoustical Sealant: As specified in Section 07 92 00 "JOINT SEALANTS."

F. Thermal Insulation: As specified in Section 07 21 00 "THERMAL INSULATION."

G. Vapor Retarder: As specified in Section 07 21 00 "THERMAL INSULATION."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames and framing, for compliance with requirements and other conditions affecting performance.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLYING AND FINISHING PANELS, GENERAL

A. Comply with ASTM C 840.

B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.

C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.

D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.

E. Form control and expansion joints with space between edges of adjoining gypsum panels.

F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.

1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. in area.
2. Fit gypsum panels around ducts, pipes, and conduits.
3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- wide joints to install sealant.

G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments, except floors. Provide 1/4-to 1/2-inch-wide spaces at these locations, and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

I. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and with manufacturer's written recommendations for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.

J. Install sound attenuation blankets before installing gypsum panels, unless blankets are readily installed after panels have been installed on one side.

3.3 APPLYING INTERIOR GYPSUM BOARD

A. Install interior gypsum board in the following locations:

1. Regular Type: Vertical surfaces, unless otherwise indicated.
2. Type X: As indicated on Drawings and Where required for fire-resistance-rated assembly.
3. Type C: Where required for specific fire-resistance-rated assembly indicated.
4. Ceiling Type: Ceiling surfaces.
5. Abuse-Resistant Type: As indicated on Drawings
6. Moisture- and Mold-Resistant Type: As indicated on Drawings

B. Single-Layer Application:

1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing, unless otherwise indicated.
2. On partitions/walls, apply gypsum panels vertically (parallel to framing, unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.

   a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
   b. At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.

3. On Z-furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

C. Multilayer Application:

1. On ceilings, apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints 1 framing member, 16 inches minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.
2. On partitions/walls, apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.
3. On Z-furring members, apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.
4. Fastening Methods: Fasten base layers and face layers separately to supports with screws, or as indicated or required by fire-resistant-rated assembly.

D. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written recommendations and temporarily brace or fasten gypsum panels until fastening adhesive has set.

3.4 APPLYING EXTERIOR GYPSUM PANELS FOR CEILINGS AND SOFFITS

A. Apply panels perpendicular to supports, with end joints staggered and located over supports.

1. Install with 1/4-inch open space where panels abut other construction or structural penetrations.
2. Fasten with corrosion-resistant screws.

3.5 APPLYING TILE BACKING PANELS

A. Cementitious Backer Units: ANSI A108.11, at showers, tubs, and where indicated.

B. Areas Not Subject to Wetting: Install regular-type gypsum wallboard panels to produce a flat surface except at showers, tubs, and other locations indicated to receive water-resistant panels.

C. Where tile backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.

3.6 INSTALLING TRIM ACCESSORIES

A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Control Joints: Install control joints according to ASTM C 840 and in specific locations approved by Architect for visual effect.

C. Interior Trim: Install in the following locations:

1. Cornerbead: Use at outside corners, unless otherwise indicated.
2. Bullnose Bead: Use where indicated
3. LC-Bead: Use where indicated
4. L-Bead: Use where indicated
5. U-Bead: Use at exposed panel edges unless otherwise indicated
6. Curved-Edge Cornerbead: Use at curved openings.

D. Exterior Trim: Install in the following locations:

1. Cornerbead: Use at outside corners.
2. LC-Bead: Use at exposed panel edges unless otherwise indicated

E. Aluminum Trim: Install in locations indicated on Drawings

3.7 FINISHING GYPSUM BOARD

A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints**,** rounded or beveled edges**,** and damaged surface areas.

C. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:

1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
2. Level 2: Panels that are substrate for tile and acoustical tile.
3. Level 3: Panels that are to receive a heavy-grade wallcovering as a final finish.
4. Level 4: At panel surfaces that will be exposed to view, unless otherwise indicated

   a. Primer and its application to surfaces are specified in other Division 09 Sections.

5. Level 5: Panels that are to receive gloss, semi-gloss or enamel paints.

   a. Primer and its application to surfaces are specified in other Division 09 Sections.

E. Glass-Mat Gypsum Sheathing Board: Finish according to manufacturer's written instructions for use as exposed soffit board.

F. Cementitious Backer Units: Finish according to manufacturer's written instructions.

3.8 PROTECTION

A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

B. Remove and replace panels that are wet, moisture damaged, and mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION 09 29 00

SECTION 09 30 00 - TILING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ceramic tile
2. Waterproof membrane
3. Tile backing panels

1.2 DEFINITIONS

A. General: Definitions in the ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.

B. Module Size: Actual tile size plus joint width indicated.

C. Face Size: Actual tile size, excluding spacer lugs.

1.3 PERFORMANCE REQUIREMENTS

A. Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C 1028:

1. Level Surfaces: Minimum 0.7 dry and minimum 0.6 wet.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show locations of each type of tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.

C. Samples for Initial Selection: For each type of tile and grout indicated. Include Samples of accessories involving color selection.

D. Qualification Data: For qualified Installer.

E. Master Grade Certificates: For each shipment, type, and composition of tile, signed by tile manufacturer and Installer.

F. Product Certificates: For each type of product, signed by product manufacturer.

G. Material Test Reports: For each tile-setting and -grouting product and special purpose tile.

1.5 QUALITY ASSURANCE

A. Source Limitations for Tile: Obtain tile of each type and color or finish from one source or producer.

1. Obtain tile of each type and color or finish from same production run and of consistent quality in appearance and physical properties for each contiguous area.

B. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from one manufacturer and each aggregate from one source or producer.

C. Source Limitations for Other Products: Obtain each of the following products specified in this Section from a single manufacturer for each product:

1. Waterproof membrane.
2. Crack isolation membrane.
3. Joint sealants.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.

B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.

C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

D. Store liquid materials in unopened containers and protected from freezing.

E. Handle tile that has temporary protective coating on exposed surfaces to prevent coated surfaces from contacting backs or edges of other units. If coating does contact bonding surfaces of tile, remove coating from bonding surfaces before setting tile.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated, but not less than one (1) un-opened box of each type and color.

PART 2 - PRODUCTS

2.1 PRODUCTS, GENERAL

A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.

1. Provide tile complying with Standard grade requirements unless otherwise indicated.

B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other PART 2 articles, ANSI standards referenced by TCA installation methods specified in tile installation schedules, and other requirements specified.

C. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.

D. Mounting: For factory-mounted tile, provide back-or edge-mounted tile assemblies as standard with manufacturer unless otherwise indicated.

1. Where tile is indicated for installation in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for installation indicated and has a record of successful in-service performance.

E. Factory-Applied Temporary Protective Coating: Where indicated under tile type, protect exposed surfaces of tile against adherence of mortar and grout by precoating with continuous film of petroleum paraffin wax, applied hot. Do not coat unexposed tile surfaces.

2.2 TILE PRODUCTS

A. Unglazed ceramic mosaic floor tile.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. American Olean; Division of Dal-Tile International Inc.
b. Crossville, Inc.

c. Daltile; Division of Dal-Tile International Inc.
d. Deutsche Steinzeug America, Inc.
e. Interceramic
f. Lone Star Ceramics Company
g. Grupo Porcelanite
h. Portobello America, Inc.
i. Seneca Tiles, Inc.

2. Composition: Impervious natural clay or porcelain
3. Module Size: 2 by 2 inches
4. Thickness: 1/4 inch.
5. Face: Pattern of design indicated, with cushion edges.
6. Surface: Slip-resistant, with abrasive admixture.
7. Tile Color and Pattern: As selected by Architect from manufacturer's full range
8. Grout Color: As selected by Architect from manufacturer's full range
9. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:

a. Base Cove: Cove, module size 2 by 1 inch.
b. Base Cap for Portland Cement Mortar Installations: Bead (bullnose), module size 2 by 1 inch.
c. Base Cap for Thin-Set Mortar Installations: Surface bullnose, module size 2 by 2 inches.
d. External Corners for Portland Cement Mortar Installations: Bead (bullnose), module size 2 by 2 inch.
e. External Corners for Thin-Set Mortar Installations: Surface bullnose, module size 2 by 2 inches.
f. Internal Corners: Cove, module size
g. Tapered Transition Tile: Shape designed to effect transition between thickness of tile floor and adjoining floor finishes of different thickness, tapered to provide reduction in thickness from 1/2 to 1/4 inch across nominal 4-inch dimension.

2.3 THRESHOLDS

A. General: Fabricate to sizes and profiles indicated or required to provide transition between adjacent floor finishes.

1. Bevel edges at 1:2 slope, with lower edge of bevel aligned with or up to 1/16 inch above adjacent floor surface. Finish bevel to match top surface of threshold. Limit height of threshold to 1/2 inch or less above adjacent floor surface.

B. Marble Thresholds: ASTM C 503, with a minimum abrasion resistance of 12 per ASTM C 1353 or ASTM C 241 and with honed finish.

1. Description: Uniform, fine- to medium-grained white stone with gray veining.
2. Description: Match COTR's sample.

2.4 TILE BACKING PANELS

A. Cementitious Backer Units: ANSI A118.9 or ASTM C 1325, in maximum lengths available to minimize end-to-end butt joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. C-Cure; C-Cure Board 990.
   b. Custom Building Products; Wonderboard.
   c. FinPan, Inc.; Util-A-Crete Concrete Backer Board.
   d. USG Corporation; DUROCK Cement Board.

2. Thickness: As indicated.

B. Fiber-Cement Underlayment: ASTM C 1288, in maximum lengths available to minimize end-to-end butt joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. CertainTeed Corp.; FiberCement BackerBoard.
   b. James Hardie; Hardiebacker 500.

2. Thickness: As indicated.

2.5 WATERPROOF MEMBRANE

A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.10 and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Chlorinated Polyethylene Sheet: Nonplasticized, chlorinated polyethylene faced on both sides with nonwoven polyester fabric; 0.030-inch nominal thickness.

C. PVC Sheet: Two layers of PVC sheet heat-fused together and to facings of nonwoven polyester; 0.040-inch nominal thickness.

D. Polyethylene Sheet: Polyethylene faced on both sides with fleece webbing; 0.008-inch nominal thickness.

E. Fabric-Reinforced, Modified-Bituminous Sheet: Self-adhering, SBS-modified-bituminous sheet with woven reinforcement facing; 0.040-inch nominal thickness.

F. Fabric-Reinforced, Fluid-Applied Membrane: System consisting of liquid-latex rubber or elastomeric polymer and continuous fabric reinforcement.

G. Latex-Portland Cement: Flexible mortar consisting of cement-based mix and latex additive.

H. Urethane Waterproofing and Tile-Setting Adhesive: One-part, liquid-applied urethane in a consistency suitable for trowel application and intended for use as both waterproofing and tile-setting adhesive in a two-step process.

2.6 CRACK ISOLATION MEMBRANE

A. General: Manufacturer's standard product**,** selected from the following that complies with ANSI A118.12 for standard performance and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Chlorinated Polyethylene Sheet: Nonplasticized, chlorinated polyethylene faced on both sides with nonwoven polyester fabric; 0.030-inch nominal thickness.

C. PVC Sheet: Two layers of PVC sheet heat-fused together and to facings of nonwoven polyester; 0.040-inch nominal thickness.

D. Polyethylene Sheet: Polyethylene faced on both sides with fleece webbing; 0.008-inch nominal thickness.

E. Corrugated Polyethylene: Corrugated polyethylene with dovetail-shaped corrugations and with anchoring webbing on the underside; 3/16-inch nominal thickness.

F. Fabric-Reinforced, Modified-Bituminous Sheet: Self-adhering, modified-bituminous sheet with fabric reinforcement facing; 0.040-inch nominal thickness.

G. Fabric-Reinforced, Fluid-Applied Membrane: System consisting of liquid-latex rubber or elastomeric polymer and fabric reinforcement.

H. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.

I. Latex-Portland Cement: Flexible mortar consisting of cement-based mix and latex additive.

J. Urethane Crack Isolation Membrane and Tile-Setting Adhesive: One-part, liquid-applied urethane, in a consistency suitable for trowel application and intended for use as both waterproofing and tile-setting adhesive in a two-step process.

2.7 SETTING MATERIALS

A. Portland Cement Mortar (Thickset) Installation Materials: ANSI A108.02.

1. Cleavage Membrane: Asphalt felt, ASTM D 226, Type I (No. 15); or polyethylene sheeting, ASTM D 4397, 4.0 mils thick.
2. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches by 0.062-inch diameter; comply with ASTM A 185 and ASTM A 82 except for minimum wire size.
3. Expanded Metal Lath: Diamond-mesh lath complying with ASTM C 847.

    a. Base Metal and Finish for Interior Applications: Uncoated or zinc-coated (galvanized) steel sheet, with uncoated steel sheet painted after fabrication into lath.

b. Base Metal and Finish for Exterior Applications: Zinc-coated (galvanized) steel sheet.
c. Configuration over Studs and Furring: Flat.
d. Configuration over Solid Surfaces: Self furring.

4. Latex Additive: Manufacturer's standard water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed.

B. Dry-Set Portland Cement Mortar (Thin Set): ANSI A118.1.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Boiardi Products; a QEP company.
b. Bonsal American; an Oldcastle company.
c. Bostik, Inc.
d. C-Cure.
e. Custom Building Products.
f. Jamo Inc.
g. Laticrete International, Inc.
h. MAPEI Corporation.
i. Southern Grouts & Mortars, Inc.
j. Summitville Tiles, Inc.
k. TEC; a subsidiary of H. B. Fuller Company.

C. Medium-Bed, Latex-Portland Cement Mortar: Comply with requirements in ANSI A118.4. Provide product that is approved by manufacturer for application thickness of 5/8 inch.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Bonsal American; an Oldcastle company.
b. Bostik, Inc.
c. C-Cure.
d. Custom Building Products.
e. Jamo Inc.
f. Laticrete International, Inc.
g. MAPEI Corporation.
h. Mer-Kote Products, Inc.
i. Southern Grouts & Mortars, Inc.
j. Summitville Tiles, Inc.
k. TEC; a subsidiary of H. B. Fuller Company.

2.8 GROUT MATERIALS

A. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement and white or colored aggregate as required to produce color indicated.

B. Standard Cement Grout: ANSI A118.6.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Boiardi Products; a QEP company.
b. Bonsal American; an Oldcastle company.
c. Bostik, Inc.
d. C-Cure.
e. Custom Building Products.
f. Jamo Inc.
g. Laticrete International, Inc.
h. MAPEI Corporation.
i. Southern Grouts & Mortars, Inc.
j. Summitville Tiles, Inc.
k. TEC; a subsidiary of H. B. Fuller Company.

C. Polymer-Modified Tile Grout: ANSI A118.7.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Boiardi Products; a QEP company.
b. Bonsal American; an Oldcastle company.
c. Bostik, Inc.
d. C-Cure.
e. Custom Building Products.
f. Jamo Inc.
g. Laticrete International, Inc.
h. MAPEI Corporation.
i. Southern Grouts & Mortars, Inc.
j. Summitville Tiles, Inc.
k. TEC; a subsidiary of H. B. Fuller Company.

D. Water-Cleanable Epoxy Grout: ANSI A118.3.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Atlas Minerals & Chemicals, Inc.
b. Boiardi Products; a QEP company.
c. Bonsal American; an Oldcastle company.
d. Bostik, Inc.
e. C-Cure.
f. Custom Building Products.
g. Jamo Inc.
h. Laticrete International, Inc.
i. MAPEI Corporation.

j. Mer-Kote Products, Inc.
k. Southern Grouts & Mortars, Inc.
l. Summitville Tiles, Inc.
m. TEC; a subsidiary of H. B. Fuller Company.

2. Provide product capable of withstanding continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, and certified by manufacturer for intended use.

2.9 ELASTOMERIC SEALANTS

A. General: Provide sealants, primers, backer rods, and other sealant accessories that comply with the following requirements and with the applicable requirements in Section 07 92 00 "JOINT SEALANTS".

1. Use primers, backer rods, and sealant accessories recommended by sealant manufacturer.

B. Colors: Provide colors of exposed sealants to match colors of grout in tile adjoining sealed joints unless otherwise indicated.

C. One-Part, Mildew-Resistant Silicone Sealant: ASTM C 920; Type S; Grade NS; Class 25; Uses NT, G, A, and, as applicable to nonporous joint substrates indicated, O; formulated with fungicide, intended for sealing interior ceramic tile joints and other nonporous substrates that are subject to in-service exposures of high humidity and extreme temperatures.

D. Multipart, Pourable Urethane Sealant for Use T: ASTM C 920; Type M; Grade P; Class 25; Uses T, M, A, and, as applicable to joint substrates indicated, O.

E. Chemical-Resistant Sealants: For chemical-resistant floors, provide chemical-resistant elastomeric sealant of type recommended and produced by chemical-resistant mortar and grout manufacturer for type of application indicated, with proven service record and compatibility with tile and other setting materials, and with chemical resistance equivalent to mortar/grout.

2.10 MISCELLANEOUS MATERIALS

A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.

B. Metal Edge Strips: Angle or L-shape, height to match tile and setting-bed thickness, metallic or combination of metal and PVC or neoprene base, designed specifically for flooring applications; stainless-steel, ASTM A 666, 300 Series exposed-edge material.

C. Temporary Protective Coating: Either product indicated below that is formulated to protect exposed surfaces of tile against adherence of mortar and grout; compatible with tile, mortar, and grout products; and easily removable after grouting is completed without damaging grout or tile.

1. Petroleum paraffin wax, fully refined and odorless, containing at least 0.5 percent oil with a melting point of 120 to 140 deg F per ASTM D 87.

2. Grout release in form of manufacturer's standard proprietary liquid coating that is specially formulated and recommended for use as temporary protective coating for tile.

D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

E. Grout Sealer: Manufacturer's standard product for sealing grout joints and that does not change color or appearance of grout.

2.11 MIXING MORTARS AND GROUT

A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.

B. Add materials, water, and additives in accurate proportions.

C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile.

1. Verify that substrates for setting tile are firm, dry, clean, free of coatings that are incompatible with tile-setting materials including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
2. Verify that concrete substrates for tile floors installed with adhesives, bonded mortar bed or thin-set mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.

   a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
   b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.

3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.
4. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with COTR.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with adhesives or thin-set mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.

B. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot toward drains.

C. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

D. Field-Applied Temporary Protective Coating: If indicated under tile type or needed to prevent grout from staining or adhering to exposed tile surfaces, precoat them with continuous film of temporary protective coating, taking care not to coat unexposed tile surfaces.

3.3 TILE INSTALLATION

A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 Series "Specifications for Installation of Ceramic Tile" that are referenced in TCA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.

B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

D. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.

1. For tile mounted in sheets, make joints between tile sheets same width as joints within tile sheets so joints between sheets are not apparent in finished work.
2. Where adjoining tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.
3. Where tiles are specified or indicated to be whole integer multiples of adjoining tiles on floor, base, walls, or trim, align joints unless otherwise indicated.

E. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:

1. Ceramic Mosaic Tile: 1/16 inch.

2. Glazed Wall Tile: 1/16 inch.

F. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

G. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.

1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.
2. Prepare joints and apply sealants to comply with requirements in Section 07 92 00 "JOINT SEALANTS".

H. Stone Thresholds: Install stone thresholds in same type of setting bed as adjacent floor unless otherwise indicated.

1. At locations where mortar bed (thickset) would otherwise be exposed above adjacent floor finishes, set thresholds in latex-portland cement mortar (thin set).
2. Do not extend cleavage membrane, waterproofing or crack isolation membrane under thresholds set in dry-set portland cement or latex-portland cement mortar. Fill joints between such thresholds and adjoining tile set on cleavage membrane, waterproofing or crack isolation membrane with elastomeric sealant.

I. Metal Edge Strips: Install where exposed edge of tile flooring meets carpet, wood, or other flooring that finishes flush with or below top of tile and no threshold is indicated.

J. Grout Sealer: Apply grout sealer to grout joints according to grout-sealer manufacturer's written instructions. As soon as grout sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.

3.4 TILE BACKING PANEL INSTALLATION

A. Install cementitious backer units and fiber-cement underlayment and treat joints according to ANSI A108.11 and manufacturer's written instructions for type of application indicated

3.5 WATERPROOFING INSTALLATION

A. Install waterproofing to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness and bonded securely to substrate.

B. Do not install tile or setting materials over waterproofing until waterproofing has cured and been tested to determine that it is watertight.

3.6 CRACK ISOLATION MEMBRANE INSTALLATION

A. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness and bonded securely to substrate.

B. Do not install tile or setting materials over crack isolation membrane until membrane has cured.

3.7 CLEANING AND PROTECTING

A. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.

1. Remove epoxy and latex-portland cement grout residue from tile as soon as possible.
2. Clean grout smears and haze from tile according to tile and grout manufacturer's written instructions but no sooner than 10 days after installation. Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.
3. Remove temporary protective coating by method recommended by coating manufacturer and that is acceptable to tile and grout manufacturer. Trap and remove coating to prevent drain clogging.

B. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.

C. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.

D. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

3.8 INTERIOR TILE INSTALLATION SCHEDULE

A. Interior Floor Installations, Concrete Subfloor:

1. Tile Installation F112 (TRACON): Cement mortar bed (thickset) bonded to concrete; TCA F112 and ANSI A108.1A, ANSI A108.1B or ANSI A108.1C.

2. Tile Installation F113: Thin-set mortar; TCA F113.

3. Tile Installation F121: Cement mortar bed (thickset) on waterproof membrane; TCA F121 and ANSI A108.1A, ANSI A108.1B or ANSI A108.1C.

4. Tile Installation F122: Thin-set mortar on waterproof membrane; TCA F122.

5. Tile Installation F125A: Thin-set mortar on crack isolation membrane; TCA F125A.

END OF SECTION 09 30 00

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SECTION 09 51 13 - ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes acoustical panels and exposed suspension systems for ceilings.

B. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete at ceilings.

1.2 DEFINITIONS

A. AC: Articulation Class.

B. CAC: Ceiling Attenuation Class.

C. LR: Light Reflectance coefficient.

D. NRC: Noise Reduction Coefficient.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension system members.
2. Method of attaching hangers to building structure.

    a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.

3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
4. Minimum Drawing Scale: 1/8 inch = 1 foot

C. Samples for Initial Selection: For components with factory-applied color finishes.

D. Qualification Data: For testing agency.

E. Field quality-control test reports.

F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each acoustical panel ceiling.

G. Research/Evaluation Reports: For each acoustical panel ceiling and components.

H. Maintenance Data: For finishes to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Acoustical Testing Agency Qualifications: An independent testing laboratory, or an NVLAP-accredited laboratory, with the experience and capability to conduct the testing indicated. NVLAP-accredited laboratories must document accreditation, based on a "Certificate of Accreditation" and a "Scope of Accreditation" listing the test methods specified.

B. Source Limitations:

1. Acoustical Ceiling Panel: Obtain each type through one source from a single manufacturer.
2. Suspension System: Obtain each type through one source from a single manufacturer.

C. Source Limitations: Obtain each type of acoustical ceiling panel and supporting suspension system through one source from a single manufacturer.

D. Fire-Test-Response Characteristics: Provide acoustical panel ceilings that comply with the following requirements:

1. Fire-Resistance Characteristics: Where indicated, provide acoustical panel ceilings identical to those of assemblies tested for fire resistance per ASTM E 119 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.

   a. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another testing and inspecting agency.
   b. Identify materials with appropriate markings of applicable testing and inspecting agency.

2. Surface-Burning Characteristics: Provide acoustical panels with the following surface-burning characteristics complying with ASTM E 1264 for Class A materials as determined by testing identical products per ASTM E 84.

E. Preinstallation Conference: Conduct conference at Project site.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical panels, suspension system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

C. Handle acoustical panels carefully to avoid chipping edges or damaging units in any way.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical panel ceiling installation.

1.7 COORDINATION

A. Coordinate layout and installation of acoustical panels and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Acoustical Ceiling Panels: Full-size panels equal to 2.0 percent of quantity installed but not less than four (4) unopened boxes for each type and finish.
2. Suspension System Components: Quantity of each exposed component equal to 2.0 percent of quantity installed.
3. Hold-Down Clips: Equal to 2.0 percent of quantity installed.

PART 2 - PRODUCTS

2.1 ACOUSTICAL PANELS, GENERAL

A. Acoustical Panel Standard: Provide manufacturer's standard panels of configuration indicated that comply with ASTM E 1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances, unless otherwise indicated.

1. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches away from test surface per ASTM E 795.

B. Acoustical Panel Colors and Patterns: Match appearance characteristics indicated for each product type.

1. Where appearance characteristics of acoustical panels are indicated by referencing pattern designations in ASTM E 1264 and not manufacturers' proprietary product designations, provide products selected by COR from each manufacturer's full range that comply with requirements indicated for type, pattern, color, light reflectance, acoustical performance, edge detail, and size.

C. Broad Spectrum Antimicrobial Fungicide and Bactericide Treatment: Provide acoustical panels treated with manufacturer's standard antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested according to ASTM D 3273 and evaluated according to ASTM D 3274 or ASTM G 21.

2.2 ACOUSTICAL PANELS FOR ACOUSTICAL PANEL CEILING

A. ACT-1: Fiberglass Ceiling Panels: Subject to compliance with requirements, provide the product indicated on Drawings, or approved equal.

1. Modular Size: 24” x 24” x 1-1/2”
2. Edge Profile: Reveal
3. Color: White
4. NRC: 1.00
5. CAC: 26
6. Light Reflectance: 0.84
7. Antimicrobial Treatment: Broad spectrum fungicide and bactericide based.
8. Fire Rating: Class A
9. Grid Type: 15/16”

B. ACT-2: Fiberglass Ceiling Panels: Subject to compliance with requirements, provide the product indicated on Drawings, or approved equal.

1. Modular Size: 24” x 24” x 1-1/2”
2. Edge Profile: Reveal
3. Color: Black
4. NRC: 1.00
5. CAC: 26
6. Light Reflectance: 0.03
7. Antimicrobial Treatment: Broad spectrum fungicide and bactericide based.
8. Fire Rating: Class A
9. Grid Type: 15/16”

C. Metal Clip-On Panels: Subject to compliance with requirements, provide the product indicated on Drawings, or approved equal.

1. Modular Size: 24” x 24”
2. Edge Profile: 1/8” Reveal
3. Perforations: M15 (Rd 1612)
4. Color: Silverlume
5. NRC: 0.90
6. CAC: N/A
7. Light Reflectance: 0.77
8. Fire Rating: Class A
9. Grid Type: 15/16”

D. Antimicrobial Treatment: Broad spectrum fungicide and bactericide based.

2.3 METAL SUSPENSION SYSTEMS, GENERAL

A. Metal Suspension System Standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C 635.

B. Finishes and Colors, General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Provide manufacturer's standard factory-applied finish for type of system indicated.

1. High-Humidity Finish: Comply with ASTM C 635 requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated.

C. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements as indicated on Drawing S001 of the structural drawings.

a. Type: Postinstalled expansion anchors.
b. Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition.
c. Corrosion Protection: Stainless-steel components complying with ASTM F 593 and ASTM F 594, Group 1 Alloy 304 or 316 for bolts; Alloy 304 or 316 for anchor.
d. Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.

D. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:

1. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
2. Stainless-Steel Wire: ASTM A 580/A 580M, Type 304, nonmagnetic.
3. Nickel-Copper-Alloy Wire: ASTM B 164, nickel-copper-alloy UNS No. N04400.
4. Size: Select wire diameter so its stress at 3 times hanger design load (ASTM C 635, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- diameter wire.

E. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.

F. Hold-Down Clips: Where indicated, provide manufacturer's standard hold-down clips spaced 24 inches o.c. on all cross tees.

G. Impact Clips: Where indicated, provide manufacturer's standard impact-clip system designed to absorb impact forces against acoustical panels.

2.4 METAL SUSPENSION SYSTEM FOR ACOUSTICAL PANEL CEILING

A. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Armstrong World Industries, Inc.
2. BPB USA
3. CertainTeed
4. Chicago Metallic Corporation
5. Ecophon CertainTeed, Inc.
6. USG Interiors, Inc.

2.5 METAL EDGE MOLDINGS AND TRIM

A. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Armstrong World Industries, Inc.
2. BPB USA
3. CertainTeed
4. Chicago Metallic Corporation
5. Fry Reglet Corporation
6. Gordon, Inc.
7. USG Interiors, Inc

B. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension system runners.

1. Provide manufacturer's standard edge moldings that fit acoustical panel edge details and suspension systems indicated and that match width and configuration of exposed runners, unless otherwise indicated.
2. For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.
3. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.

C. Extruded-Aluminum Edge Moldings and Trim: Where indicated, provide manufacturer's extruded-aluminum edge moldings and trim of profile indicated or referenced by manufacturer's designations, including splice plates, corner pieces, and attachment and other clips, complying with seismic design requirements and the following:

1. Aluminum Alloy: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of aluminum extrusions complying with ASTM B 221 for Alloy and Temper 6063-T5.
2. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.
3. Conversion-Coated Finish: AA-M12C42 (Chemical Finish: cleaned with inhibited chemicals; acid-chromate-fluoride-phosphate conversion coating).
4. Conversion-Coated and Factory-Primed Finish: AA-M12C42R1x (Chemical Finish: cleaned with inhibited chemicals; acid-chromate-fluoride-phosphate conversion coating; organic coating as follows):

a. Manufacturer's standard, factory-applied prime-coat finish ready for field painting.

5. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
6. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; organic coating: as specified below). Apply baked enamel complying with paint manufacturer's written instructions for cleaning, conversion coating, and painting.

a. Organic Coating: Thermosetting, primer/topcoat system with a minimum dry film thickness of 0.8 to 1.2 mils.

2.6 ACOUSTICAL SEALANT

A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Acoustical Sealant for Exposed and Concealed Joints:

a. Pecora Corporation; AC-20 FTR Acoustical and Insulation Sealant.
b. USG Corporation; SHEETROCK Acoustical Sealant.

2. Acoustical Sealant for Concealed Joints:

a. OSI Sealants, Inc.; Pro-Series SC-175 Rubber Base Sound Sealant.
b. Pecora Corporation; BA-98.
c. Tremco, Inc.; Tremco Acoustical Sealant.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

3.3 INSTALLATION

A. General: Install acoustical panel ceilings to comply with ASTM C 636 and seismic design requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
5. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
6. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
7. Do not attach hangers to steel deck tabs.
8. Do not attach hangers to steel roof deck. Attach hangers to structural members.
9. Space hangers not more than 48 inches o.c. along each member supported directly from hangers, unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.
10. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.

C. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.

1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
2. Screw attach moldings to substrate at intervals not more than 16 inches o.c. and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter corners accurately and connect securely.
3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

D. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

E. Install acoustical panels with undamaged edges and fit accurately into suspension system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.

1. Arrange directionally patterned acoustical panels as follows:

a. Install panels with pattern running in one direction parallel to short axis of space.

2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension system runners and moldings.
3. For reveal-edged panels on suspension system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
4. For reveal-edged panels on suspension system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension system surfaces and panel faces flush with bottom face of runners.
5. Install hold-down clips in areas indicated, in areas required by authorities having jurisdiction, and for fire-resistance ratings; space as recommended by panel manufacturer's written instructions, unless otherwise indicated.

3.4 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 09 51 13

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SECTION 09 65 13 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Resilient base.
2. Resilient stair accessories.
3. Resilient molding accessories.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples for Initial Selection: For each type of product indicated.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F.

1.4 PROJECT CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 95 deg F, in spaces to receive resilient products during the following time periods:

1. 48 hours before installation.
2. During installation.
3. 48 hours after installation.

B. Until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Install resilient products after other finishing operations, including painting, have been completed.

1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Furnish not less than 10 linear feet for every 500 linear feet or fraction thereof, of each type, color, pattern, and size of resilient but not less than four (4) unopened boxes for each type and finish product installed.

PART 2 - PRODUCTS

2.1 RESILIENT BASE

A. Resilient Base:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Armstrong World Industries, Inc.
b. Flexco, Inc.
c. Johnsonite
d. Roppe Corporation, USA.

B. Resilient Base Standard: ASTM F 1861.

1. Material Requirement: Type TV (vinyl, thermoplastic) Type TS (rubber, vulcanized thermoset) or Type TP (rubber, thermoplastic).
2. Manufacturing Method: Group I (solid, homogeneous) or Group II (layered).
3. Style: Cove (base with toe)

C. Minimum Thickness: 0.125 inch

D. Height: 4 inches

E. Lengths: Cut lengths 48 inches long or coils in manufacturer's standard length.

F. Outside Corners: Preformed

G. Inside Corners: Preformed

H. Finish: If not otherwise indicated to be as selected by COTR from manufacturer's full range.

I. Colors and Patterns: If not otherwise indicated to be as selected by COTR from full range of industry colors.

2.2 RESILIENT FLOOR

A. Resilient Floor:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Burke Mercer Flooring Products; Division of Burke Industries, Inc.
b. Endura Rubber Flooring; Division of Burke Industries, Inc.
c. Estrie Products International; American Biltrite (Canada) Ltd.
d. Flexco, Inc.

e. Johnsonite
f. Mondo Rubber International, Inc.
g. Musson, R. C. Rubber Co.
h. Nora Rubber Flooring; Freudenberg Building Systems, Inc.
i. PRF USA, Inc.
j. R.C.A. Rubber Company (The).
k. Roppe Corporation, USA.
l. VPI, LLC; Floor Products Division.

B. Resilient Floor Standard: ASTM F 2169.

1. Material Requirement: Type TS (rubber, vulcanized thermoset).
2. Surface Design:

a. Class 2, Pattern: As indicated on the Drawings.

3. Manufacturing Method: Group 2 tread with contrasting color for the visually impaired.

C. Thickness: 1/4 inch and tapered to back edge.

D. Colors and Patterns: If not otherwise indicated, to be as selected by COTR from full range of industry colors.

2.3 RESILIENT MOLDING ACCESSORY

A. Resilient Molding Accessory:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Burke Mercer Flooring Products; Division of Burke Industries, Inc.
b. Flexco, Inc.
c. Johnsonite
d. R.C.A. Rubber Company (The).
e. Roppe Corporation, USA.
f. VPI, LLC; Floor Products Division.

B. Description: Carpet edge for glue-down applications, Nosing for carpet, Nosing for resilient floor covering, Reducer strip for resilient floor covering, Joiner for tile and carpet, or Transition strips.

C. Material: Vinyl

D. Profile and Dimensions: As indicated

E. Colors and Patterns: If not otherwise indicated, to be selected by COTR from full range of industry colors.

2.4 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by manufacturer to suit resilient products and substrate conditions indicated.

C. Metal Edge Strips: Extruded aluminum with mill finish of width shown, of height required to protect exposed edges of tiles, and in maximum available lengths to minimize running joints.

D. Floor Polish: Provide protective liquid floor polish products as recommended by resilient stair tread manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates for Resilient Stair Treads and Accessories: Prepare according to ASTM F 710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer.
4. Moisture Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound and remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install resilient products until they are same temperature as the space where they are to be installed.

1. Move resilient products and installation materials into spaces where they will be installed at least 48 hours in advance of installation.

E. Sweep and vacuum clean substrates to be covered by resilient products immediately before installation.

3.3 RESILIENT BASE INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient base.

B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

C. Install resilient base in lengths as long as practicable without gaps at seams and with tops of adjacent pieces aligned.

D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.

E. Do not stretch resilient base during installation.

F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.

G. Preformed Corners: Install preformed corners before installing straight pieces.

3.4 RESILIENT ACCESSORY INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient accessories.

3.5 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protection of resilient products.

B. Perform the following operations immediately after completing resilient product installation:

1. Remove adhesive and other blemishes from exposed surfaces.

C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

END OF SECTION 09 65 13

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SECTION 09 65 19 - RESILIENT TILE FLOORING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vinyl composition floor tile.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples for Initial Selection: For each type of floor tile indicated.

C. Qualification Data: For qualified Installer.

D. Maintenance Data: For each type of floor tile to include in maintenance manuals.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for floor tile installation method indicated.

1. Engage an installer who employs workers for this Project who are trained or certified by manufacturer for installation techniques required.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store floor tile and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F. Store floor tiles on flat surfaces.

1.5 PROJECT CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 95 deg F, in spaces to receive floor tile during the following time periods:

1. 48 hours before installation.
2. During installation.
3. 48 hours after installation.

B. Until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Close spaces to traffic during floor tile installation.

D. Close spaces to traffic for 48 hours after floor tile installation.

E. Install floor tile after other finishing operations, including painting, have been completed.

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Floor Tile: Furnish 1 box for every 50 boxes or fraction thereof, of each type, color, and pattern of floor tile installed but not less than two (2) unopened boxes of each size, color and type of tile.

PART 2 - PRODUCTS

2.1 VINYL COMPOSITION FLOOR TILE

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. AB ColorPlus, American Biltrite (Canada) Ltd.
2. Armstrong World Industries, Inc.
3. Congoleum Corporation
4. Mannington Mills, Inc.
5. Tarkett, Inc.; NAFCO, Azrock
6. Vinylasa Tile, Distributed by American Tile Inc.

B. Tile Standard: ASTM F 1066, Class 1, solid-color tile

C. Wearing Surface: Smooth

D. Thickness: 0.125 inch

E. Size: 12 by 12 inches.

F. Colors and Patterns: If not otherwise indicated, to be selected by COTR from full range of industry colors.

2.2 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by manufacturer to suit floor tile and substrate conditions indicated.

C. Seamless-Installation Accessories:

1. Heat-Welding Bead: Manufacturer's solid-strand product for heat welding seams.

a. Color: Match floor tile

2. Chemical-Bonding Compound: Manufacturer's product for chemically bonding seams.

D. Floor Polish: Provide protective liquid floor polish products as recommended by manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of floor tile.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates: Prepare according to ASTM F 710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.
4. Moisture Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound and remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install floor tiles until they are same temperature as space where they are to be installed.

1. Move resilient products and installation materials into spaces where they will be installed at least 48 hours in advance of installation.

E. Sweep and vacuum clean substrates to be covered by resilient products immediately before installation.

3.3 FLOOR TILE INSTALLATION

A. Comply with manufacturer's written instructions for installing floor tile.

B. Lay out floor tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half tile at perimeter.

1. Lay tiles square with room axis

C. Match floor tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.

1. Lay tiles with grain direction alternating in adjacent tiles (basket-weave pattern.

D. Scribe, cut, and fit floor tiles to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.

E. Extend floor tiles into toe spaces, door reveals, closets, and similar openings. Extend floor tiles to center of door openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on floor tiles as marked on substrates. Use chalk or other nonpermanent, nonstaining marking device.

G. Install floor tiles on covers for telephone and electrical ducts, building expansion-joint covers, and similar items in finished floor areas. Maintain overall continuity of color and pattern between pieces of tile installed on covers and adjoining tiles. Tightly adhere tile edges to substrates that abut covers and to cover perimeters.

H. Adhere floor tiles to flooring substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protection of floor tile.

B. Perform the following operations immediately after completing floor tile installation:

1. Remove adhesive and other blemishes from exposed surfaces.
2. Sweep and vacuum surfaces thoroughly.
3. Damp-mop surfaces to remove marks and soil.

C. Protect floor tile products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover floor tile until Substantial Completion.

END OF SECTION 09 65 19

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SECTION 09 68 13 - TILE CARPETING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes modular, carpet tile.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include manufacturer's written data on physical characteristics, durability, and fade resistance. Include installation recommendations for each type of substrate.

B. Shop Drawings: Show the following:

1. Columns, doorways, enclosing walls or partitions, built-in cabinets, and locations where cutouts are required in carpet tiles.
2. Carpet tile type, color, and dye lot.
3. Type of subfloor.
4. Type of installation.
5. Pattern of installation.
6. Pattern type, location, and direction.
7. Pile direction.
8. Type, color, and location of insets and borders.
9. Type, color, and location of edge, transition, and other accessory strips.
10. Transition details to other flooring materials.

C. Samples: For each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.

1. Carpet Tile: Full-size Sample.
2. Exposed Edge, Transition, and other Accessory Stripping: 12-inch- long Samples.

D. Product Schedule: For carpet tile. Use same designations indicated on Drawings.

E. Qualification Data: For Installer.

F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency.

G. Maintenance Data: For carpet tiles to include in maintenance manuals. Include the following:

1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

H. Warranty: Special warranty specified in this Section.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is certified by the Floor Covering Installation Board or who can demonstrate compliance with its certification program requirements.

B. Preinstallation Conference: Conduct conference at Project site.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI 104, Section 5, "Storage and Handling."

1.5 PROJECT CONDITIONS

A. Comply with CRI 104, Section 7.2, "Site Conditions; Temperature and Humidity" and Section 7.12, "Ventilation."

B. Environmental Limitations: Do not install carpet tiles until wet work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended by carpet tile manufacturer.

D. Where demountable partitions or other items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.6 WARRANTY

A. Special Warranty for Carpet Tiles: Manufacturer's standard form in which manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.

1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
2. Failures include, but are not limited to, more than 10 percent loss of face fiber, edge raveling, snags, runs, loss of tuft bind strength, dimensional stability, excess static discharge and delamination.
3. Warranty Period: 10 years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Carpet Tile: Full-size units equal to 50 percent of amount installed in the Cab and 10 percent for each other type indicated, but not less than three (3) unopened boxes of each type, color and pattern of tile

PART 2 - PRODUCTS

2.1 CARPET TILE

A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Interface Modular Carpet Tiles

a. Color/Pattern: As indicated on the Drawings.

B. Primary Backing/Backcoating: Manufacturer's standard composite materials

C. Secondary Backing: Manufacturer's standard material

D. Size: 50 cm x 50 cm

E. Applied Soil-Resistance Treatment: Manufacturer's standard material

F. Antimicrobial Treatment: Manufacturer's standard material

G. Performance Characteristics: As follows:

1. Dry Breaking Strength: Not less than 100 lbf per ASTM D 2646.
2. Tuft Bind: Not less than 15 pounds for loop pile and 6 pounds for cut pile per ASTM D 1335.
3. Delamination: ASTM D 3936.
4. Dimensional Tolerance: Within 1/32 inch of specified size dimensions, as determined by physical measurement.
5. Dimensional Stability: 0.2 percent or less per ISO 2551 (Aachen Test).
6. Resistance to Insects: Comply with AATCC 24.
7. Noise Reduction Coefficient (NRC): per ASTM C 423.
8. Colorfastness to Crocking: Not less than 4, wet and dry, per AATCC 165.
9. Colorfastness to Light: AATCC 16, Option E.
10. Antimicrobial Activity: Not less than 2-mm halo of inhibition for gram-positive bacteria; not less than 1-mm halo of inhibition for gram-negative bacteria; no fungal growth; per AATCC 174.
11. Electrostatic Propensity: AATCC 134.

2.2 INSTALLATION ACCESSORIES

A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.

B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive type to suit products and subfloor conditions indicated, that complies with flammability requirements for installed carpet tile and is recommended by carpet tile manufacturer for releasable installation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance. Examine carpet tile for type, color, pattern, and potential defects.

B. Concrete Subfloors: Verify that concrete slabs comply with ASTM F 710 and the following:

1. Slab substrates are dry and free of curing compounds, sealers, hardeners, and other materials that may interfere with adhesive bond. Determine adhesion and dryness characteristics by performing bond and moisture tests recommended by carpet tile manufacturer.
2. Subfloor finishes comply with requirements specified in Section 03 30 00 "Cast-in-Place Concrete" for slabs receiving carpet tile.
3. Subfloors are free of cracks, ridges, depressions, scale, and foreign deposits.

3.2 PREPARATION

A. General: Comply with CRI 104, Section 6.2, "Site Conditions; Floor Preparation," and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile installation.

B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch wide or wider and protrusions more than 1/32 inch, unless more stringent requirements are required by manufacturer's written instructions.

C. Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by carpet tile manufacturer.

D. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.3 INSTALLATION

A. General: Comply with CRI 104, Section 14, "Carpet Modules," and with carpet tile manufacturer's written installation instructions.

B. Installation Method: As recommended in writing by carpet tile manufacturer

C. Maintain dye lot integrity. Do not mix dye lots in same area.

D. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.

E. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on finish flooring as marked on subfloor. Use nonpermanent, nonstaining marking device.

G. Install pattern parallel to walls and borders.

3.4 CLEANING AND PROTECTION

A. Perform the following operations immediately after installing carpet tile:

1. Remove excess adhesive, seam sealer, and other surface blemishes using cleaner recommended by carpet tile manufacturer.
2. Remove yarns that protrude from carpet tile surface.
3. Vacuum carpet tile using commercial machine with face-beater element.

B. Protect installed carpet tile to comply with CRI 104, Section 16, "Protection of Indoor Installations."

C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION 09 68 13

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SECTION 09 68 13.10 – CONDUCTIVE TILE CARPETING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes ESD conductive carpet tiles.

B. The ESD carpet tiles shall be applied using the groundable, ESD method, using kits provided by manufacturer, on floor where indicated.

1.2 SUBMITTALS

A. Product Data: For the following, including installation recommendations for each type of substrate:

1. Carpet: For each type indicated. Include manufacturer's written data on physical characteristics, durability, and fade resistance.

2. Floor Preparation Materials: Provide written data on physical characteristics, and installation method.

B. Shop Drawings: Show the following:

1. Columns, doorways, enclosing walls or partitions, built-in cabinets, and locations where cutouts are required in carpet.
2. Existing flooring materials to be removed.
3. Existing flooring materials to remain.
4. Carpet type, color, and dye lot.
5. Seam locations, types, and methods.
6. Type of subfloor.
7. Type of installation.
8. Pile direction.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency.

D. Maintenance Data: For carpet to include in maintenance manuals. Include the following:

1. Methods for maintaining carpet tiles, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
2. Precautions for cleaning materials and methods that could be detrimental to carpet tiles.

E. Warranties: Special warranties specified in this Section.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is certified by the Floor Covering Installation Board or who can demonstrate compliance with its certification program requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI 104, Section 5, "Storage and Handling."

1.5 PROJECT CONDITIONS

A. Comply with CRI 104, Section 7.2, "Site Conditions; Temperature and Humidity" and Section 7.12, "Ventilation."

B. Environmental Limitations: Do not install carpet until wet work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

C. Do not install carpet tiles over concrete slabs until slabs have cured, are sufficiently dry to bond with adhesive, and have pH range recommended by carpet manufacturer.

D. Where demountable partitions or other items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.6 WARRANTY

A. Special Warranty for Carpet Tiles: Manufacturer's standard form in which manufacturer agrees to repair or replace components of carpet installation that fail in materials or workmanship within specified warranty period.

1. Warranty does not include deterioration or failure of carpet tiles due to unusual traffic, failure of substrate, vandalism, or abuse.
2. Failures include, but are not limited to, more than 10 percent loss of face fiber, edge raveling, snags, runs, loss of tuft bind strength, and delamination.
3. Warranty Period: 10 years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Carpet Tiles: Full-size tiles equal to 5 percent of amount installed for each type indicated, but not less than 10 sq. yd.

PART 2 - PRODUCTS

2.1 CARPET TILE

A. Basis-of-Design:

1. Static Smart Environments by Julie Industries.

a. Color/Pattern - As Indicated on the Drawings

B. Fiber Content: Performa SD Type nylon 6.

C. Fiber Type: Continuous conductive StaticSmart™ FibreLink monofilament in every tuft.

D. Pile Characteristic: Textured graphic loop pile.

E. Pile Height: High 6/32 inch, low 4/32 inch.

F. Stitches: 10 per inch.

G. Total Weight: 98.98 oz/sq. yd. for finished carpet tile.

H. Backing System: Dissipative StaticWorx™ backing, 100 percent PVC-free recyclable, made from recycled material.

1. Carpet Tile which does not need to be installed using the StaticSmart ESD Carpet system may be manufactured with different backing system. Contractor may choose the alternate backing system offered by manufacturer.

I. Size: 24 by 24 inches.

J. Adhesives: Conductive releasable adhesive for carpet tile 1.0 x 10^6 Ohms Rtt.

1. Adhesive for carpet tile not installed over access flooring does not require conductive adhesive. Provide adhesive recommended by the manufacturer.

K. Grounding Frequency: 1 per 1,000 sq. ft.

L. Performance Characteristics: As follows:

1. Critical Radiant Flux Classification: Not less than 0.45 W/sq. cm.
2. Dry Breaking Strength: Not less than 100 lbf per ASTM D 2646.
3. Tuft Bind: Not less than 3 lbf per ASTM D 1335.
4. Delamination: Not less than 3.5 lbf/in. per ASTM D 3936.
5. Dimensional Tolerance: Within 1/32 inch of specified size dimensions, as determined by physical measurement.
6. Dimensional Stability: 0.2 percent or less per ISO 2551 (Aachen Test).
7. Resistance to Insects: Comply with AATCC 24.
8. Colorfastness to Crocking: Not less than 4, wet and dry, per AATCC 165.

9. Colorfastness to Light: Not less than 4 after 40 AFU (AATCC fading units) per AATCC 16, Option E.
10. Antimicrobial Activity: Not less than 2-mm halo of inhibition for gram-positive bacteria; not less than 1-mm halo of inhibition for gram-negative bacteria; no fungal growth; per AATCC 174.
11. Electrical Resistance:

    a. ESD S7.1/NFPA 99 Resistive Characterization of Materials: Six or more readings from surface to groundable point. Tested with an applied voltage of 100V. Measured in Ohms, 1.0×10^5 minimum, 5.0×10^8 maximum.
    b. ESD S7.1/NFPA 99 Resistance Characterization of Materials: Six or more readings between electrodes placed 1 foot apart. Tested with an applied voltage of 100V. Measured in Ohms, $2.5 \text{ X } 10^4$, minimum, 5.0×10^7 maximum.
    c. Electrical Resistance/Voltage Test ANSI/ESD S-20.20, compliant when using approved conductive footware system. Results within recommended range $<35 \times 10^6$ Ohm or $<35 \times 10^6$ Ohm or <100 volts.
    d. Roller Caster Electrical Test (CET) Assessment. After 100,000 chair caster cycles there was no depreciable change in conductivity or electrical performance.

12. Groundable Path: StaticSmart™ Ground Strip or RTG Connector ™ Kit.

    a. Carpet tile installed in locations other than access floor will not require these kits.

13. Grounding Frequency: 1 per 1,000 sq. ft.

2.2 INSTALLATION ACCESSORIES

A. Adhesives: Water-resistant, mildew-resistant, nonstaining type to suit products and subfloor conditions indicated, that complies with flammability requirements for installed carpet and is recommended or provided by carpet manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet performance. Examine carpet for type, color, pattern, and potential defects.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Condition and Cleaning of Subfloor: Subfloor shall be structurally sound. Clean subfloor to remove mud, oil, grease, and other contaminating factors before installation of floor leveling compound.

B. Priming Subfloor: Prime VCT using primer recommended by leveling compound manufacturer.

C. Expansion Joints: Allow joints to continue through the floor leveling compound at the same width.

3.3 CARPET INSTALLATION

A. Comply with CRI 104 and carpet manufacturer's written installation instructions for the following:

1. Direct-Glue-Down Installation: Comply with CRI 104, Section 9, "Direct Glue-Down Installation."
2. Double-Glue-Down Installation: Comply with CRI 104, Section 10, "Double Glue-Down Installation."
3. Preapplied Adhesive Installation: Comply with CRI 104, Section 11.4, "Pre-Applied Adhesive Systems (Peel and Stick)."
4. Stretch-in Installation: Comply with CRI 104, Section 12, "Stretch-in Installation."

B. Comply with carpet manufacturer's written recommendations and Shop Drawings for seam locations and direction of carpet; maintain uniformity of carpet direction and lay of pile. At doorways, center seams under the door in closed position.

1. Installation of Carpet Tile in Non-Access Floor Locations: Installation for groundable path is not necessary in locations indicated on drawings that are not part of the access floor.

C. Cut and fit carpet to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet manufacturer.

D. Extend carpet into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

E. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on finish flooring as marked on subfloor. Use nonpermanent, nonstaining marking device.

F. Install pattern parallel to walls and borders to comply with CRI 104, Section 15, "Patterned Carpet Installations" and with carpet manufacturer's written recommendations.

3.4 CLEANING AND PROTECTING

A. Perform the following operations immediately after installing carpet:

1. Remove excess adhesive, seam sealer, and other surface blemishes using cleaner recommended by carpet manufacturer.
2. Remove yarns that protrude from carpet surface.
3. Vacuum carpet using commercial machine with face-beater element.

B. Protect installed carpet to comply with CRI 104, Section 16, "Protection of Indoor Installations."

C. Protect carpet against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet manufacturer and carpet adhesive manufacturer.

END OF SECTION 09 68 13.10

SECTION 09 91 00 - PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes surface preparation and field painting of exposed interior and exterior items and surfaces, including, but not limited to the following:

1. Horizontal and vertical wall and ceiling surfaces.
2. Metal doors and door frames.
3. Metal access doors and frames, non-stainless steel surfaces.
4. Exterior elements, including ductwork, pipes, conduits, hand-railings where indicated.
5. Interior ductwork which is exposed in occupied spaces and which is not externally insulated where indicated to be painted.
6. Exposed interior metal piping, not externally insulated, in occupied spaces where indicated. Do not paint copper or PVC pipe.

B. Paint exposed surfaces, except where these Specifications indicate that the surface or material is not to be painted or is to remain natural. If an item or a surface is not specifically mentioned, paint the item or surface the same as similar adjacent materials or surfaces. If a color of finish is not indicated, COR will select from standard colors and finishes available.

C. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.

1. Prefinished items include the following factory-finished components:

   a. Architectural woodwork.
   b. Acoustical wall panels.
   c. Metal toilet enclosures.
   d. Metal lockers.
   e. Elevator entrance doors and frames.
   f. Elevator equipment.
   g. Finished mechanical and electrical equipment.
   h. Light fixtures.

2. Concealed surfaces include walls or ceilings in the following generally inaccessible spaces:

   a. Foundation spaces.
   b. Furred areas.
   c. Ceiling plenums.
   d. Utility tunnels.
   e. Pipe spaces.
   f. Duct shafts.
   g. Elevator shafts.

3. Finished metal surfaces include the following:

   a. Anodized aluminum.
   b. Stainless steel.
   c. Chromium plate.
   d. Copper and copper alloys.
   e. Bronze and brass.

4. Operating parts include moving parts of operating equipment and the following:

   a. Valve and damper operators.
   b. Linkages.
   c. Sensing devices.
   d. Motor and fan shafts.

5. Labels: Do not paint over UL, FMG, or other code-required labels or equipment name, identification, performance rating, or nomenclature plates.

1.2 DEFINITIONS

A. General: Standard coating terms defined in ASTM D 16 apply to this Section.

1. Flat refers to a lusterless or matte finish with a gloss range below 15 when measured at an 85-degree meter.
2. Eggshell refers to low-sheen finish with a gloss range between 20 and 35 when measured at a 60-degree meter.
3. Semigloss refers to medium-sheen finish with a gloss range between 35 and 70 when measured at a 60-degree meter.
4. Pearl is a Benjamin Moore designation for a low-luster (satin) finish.

1.3 SUBMITTALS

A. Product Data: For each paint system indicated. Include block fillers and primers.

1. Material List: An inclusive list of required coating materials. Indicate each material and cross-reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.
2. Manufacturer's Information: Manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each coating material.
3. Certification by the manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs).
4. For interior primers and finish coats to be applied in occupied portions of a building, all materials submitted shall be products identified by the manufacture as “low VOC”.
5. MSDS for each paint product used.

B. Qualification Data: For Applicator.

1.4 QUALITY ASSURANCE

A. Applicator Qualifications: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

B. Source Limitations: Obtain primers for each coating system from the same manufacturer as the finish coats.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label and the following information:

1. Product name or title of material.
2. Product description (generic classification or binder type).
3. Manufacturer's stock number and date of manufacture.
4. Contents by volume, for pigment and vehicle constituents.
5. Thinning instructions.
6. Application instructions.
7. Color name and number.
8. VOC content.

B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F. Maintain storage containers in a clean condition, free of foreign materials and residue.

1. Protect from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily.

1.6 PROJECT CONDITIONS

A. Apply waterborne paints only when temperatures of surfaces to be painted and surrounding air are between 50 and 90 deg F.

B. Do not apply paint in snow, rain, fog, or mist; or when relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

1. Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by manufacturer during application and drying periods.

1.7 EXTRA MATERIALS

A. Furnish extra paint materials from the same production run as the materials applied and in the quantities described below. Package with protective covering for storage and identify with labels describing contents. Deliver extra materials to FAA.

1. Quantity: Furnish FAA with extra paint materials in quantities indicated below:

a. Interior, Low-Luster Acrylic Finish: 1 gallon of each color applied.
b. Interior, Semigloss Acrylic Enamel: 1 gallon of each color applied.
c. Exterior, Direct to Metal Acrylic: 1 gallon.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products listed in other Part 2 articles.

2.2 PAINT MATERIALS, GENERAL

A. Material Compatibility: Provide block fillers, primers, and finish-coat materials that are compatible with one another and with the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

B. Material Quality: Provide manufacturer's best-quality paint material of the various coating types specified that are factory formulated and recommended by manufacturer for application indicated. Paint-material containers not displaying manufacturer's product identification will not be acceptable.

1. Proprietary Names: Use of manufacturer's proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Furnish manufacturer's material data and certificates of performance for proposed substitutions.

C. Chemical Components of Interior Paints and Coatings: Provide products that comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24) and the following chemical restrictions:

1. Flat Paints and Coatings: VOC content of not more than 50 g/L.
2. Non-Flat Paints and Coatings: VOC content of not more than 150 g/L.
3. Aromatic Compounds: Paints and coatings shall not contain more than 1.0 percent by weight of total aromatic compounds (hydrocarbon compounds containing one or more benzene rings).
4. Restricted Components: Paints and coatings shall not contain any of the following:

a. Acrolein
b. Acrylonitrile
c. Antimony
d. Benzene
e. Butyl benzyl phthalate
f. Cadmium
g. Di (2-ethylhexyl) phthalate
h. Di-n-butyl phthalate
i. Di-n-octyl phthalate
j. 1,2-dichlorobenzene
k. Diethyl phthalate
l. Dimethyl phthalate
m. Ethylbenzene
n. Formaldehyde
o. Hexavalent chromium
p. Isophorone
q. Lead
r. Mercury
s. Methyl ethyl ketone
t. Methyl isobutyl ketone
u. Methylene chloride
v. Naphthalene
w. Toluene (methylbenzene).

D. Colors: Provide color selections as specified in Material and Finish Schedule. If not on Material and Finish Schedule, provide colors to match adjacent surfaces.

2.3 INTERIOR PRIMERS

A. Interior Concrete and Masonry Primer: Factory-formulated alkali-resistant acrylic-latex interior primer for interior application.

1. Benjamin Moore; Regal FirstCoat Interior Latex Primer & Underbody No. 216: Applied at a dry film thickness of not less than 1.0 mil.
2. Pittsburgh Paints; 6-2 SpeedHide Interior Quick-Drying Latex Sealer: Applied at a dry film thickness of not less than 1.0 mil.
3. Sherwin-Williams; PrepRite Masonry Primer B28W300: Applied at a dry film thickness of not less than 3.0 mils.

B. Interior Gypsum Board Primer: Factory-formulated latex-based primer for interior application.

1. Benjamin Moore; Regal FirstCoat Interior Latex Primer & Underbody No. 216: Applied at a dry film thickness of not less than 1.0 mil.
2. Pittsburgh Paints; 6-2 SpeedHide Interior Quick-Drying Latex Sealer: Applied at a dry film thickness of not less than 1.0 mil.
3. Sherwin-Williams; PrepRite 200 Latex Wall Primer B28W200 Series: Applied at a dry film thickness of not less than 1.6 mils.

C. Interior Ferrous-Metal Primer: Factory-formulated quick-drying rust-inhibitive alkyd-based metal primer.

1. Benjamin Moore; IronClad Alkyd Low Lustre Medal and Wood Enamel No. 163: Applied at a dry film thickness of not less than 1.3 mils.
2. Pittsburgh Paints; 7-858 Pittsburgh Paints Industrial Rust Inhibitive Steel Primer: Applied at a dry film thickness of not less than 1.5 mils.
3. Sherwin-Williams; Kem Kromik Universal Metal Primer B50NZ6/B50WZ1: Applied at a dry film thickness of not less than 3.0 mils.

D. Interior Zinc-Coated Metal Primer: Factory-formulated galvanized metal primer.

1. Benjamin Moore; IronClad Latex Low Lustre Metal and Wood Enamel No. 363: Applied at a dry film thickness of not less than 1.6 mils.
2. Pittsburgh Paints; 90-709 Pitt-Tech One Pack Interior/Exterior Primer/Finish DTM Industrial Enamel: Applied at a dry film thickness of not less than 3.0 mils.
3. Sherwin-Williams; Galvite Paint B50W3: Applied at a dry film thickness of not less than 2.0 mils.

2.4 INTERIOR FINISH COATS

A. Interior Flat Acrylic Paint: Factory-formulated flat acrylic-emulsion latex paint for interior application.

1. Benjamin Moore; Regal Wall Satin No. 215 Premium Interior Finishes Flat Finish: Applied at a dry film thickness of not less than 1.3 mils.
2. Pittsburgh Paints; 80-Line Wallhide Interior Wall Flat Latex Paint: Applied at a dry film thickness of not less than 1.2 mils.
3. Sherwin-Williams; SuperPaint Interior Latex Flat Wall Paint, A86 Series: Applied at a dry film thickness of not less than 1.5 mils.

B. Interior Latex Enamel: Factory-formulated, proprietary latex enamel interior paint.

1. Benjamin Moore; Aqua Pearl No. 310. Applied at a dry film thickness of not less than 1.3 mils.

C. Interior Low-Luster Acrylic Enamel: Factory-formulated eggshell acrylic-latex interior enamel.

1. Benjamin Moore; Moore's Regal AquaVelvet No. 319: Applied at a dry film thickness of not less than 1.4 mils.
2. Pittsburgh Paints; 89-Line Manor Hall Interior Eggshell Wall and Trim: Applied at a dry film thickness of not less than 1.4 mils.
3. Sherwin-Williams; SuperPaint Interior Latex Satin Wall Paint A87 Series: Applied at a dry film thickness of not less than 1.6 mils.

D. Interior Semigloss Acrylic Enamel: Factory-formulated semigloss acrylic-latex enamel for interior application.

1. Benjamin Moore; Regal AquaGlo No. 333 Premium Interior Finishes Latex Semi-Gloss: Applied at a dry film thickness of not less than 1.3 mils.

2. Pittsburgh Paints; 88-110 Satinhide Interior Enamel Wall & Trim Lo-Lustre Semi-Gloss Latex: Applied at a dry film thickness of not less than 1.1 mils.
3. Sherwin-Williams; SuperPaint Interior Latex Semi-Gloss Enamel A88 Series: Applied at a dry film thickness of not less than 1.6 mils.

2.5 EXTERIOR COATINGS

A. Direct to Metal (DTM) Acrylic coating; semi-gloss or gloss as approved by COR.

1. Benjamin Moore; Industrial Maintenance Coatings M29 DTM: Applied at a dry film thickness of not less than 1.5 mils.
2. Pittsburgh Paints; Pitt-Tech DTM Industrial Enamels 90 Series: Applied at a dry film thickness of not less than 1.5 mils.
3. Sherwin-Williams; DTM Acrylic Coating, B66-100 or B66-200 Series: Applied at a dry film thickness of not less than 2.5 mils.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for paint application.

1. Proceed with paint application only after unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.
2. Start of painting will be construed as Applicator's acceptance of surfaces and conditions within a particular area.

B. Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.

1. Notify COR about anticipated problems when using the materials specified over substrates primed by others.

3.2 PREPARATION

A. General: Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of size or weight of the item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.

B. Cleaning: Before applying paint or other surface treatments, clean substrates of substances that could impair bond of the various coatings. Remove oil and grease before cleaning.

1. Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

C. Surface Preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified.

1. Provide barrier coats over incompatible primers or remove and reprime.
2. Cementitious Materials: Prepare concrete, concrete unit masonry, cement plaster, and mineral-fiber-reinforced cement panel surfaces to be painted. Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.

   a. Use abrasive blast-cleaning methods if recommended by paint manufacturer.
   b. Determine alkalinity and moisture content of surfaces by performing appropriate tests. If surfaces are sufficiently alkaline to cause the finish paint to blister and burn, correct this condition before application. Do not paint surfaces if moisture content exceeds that permitted in manufacturer's written instructions.

3. Ferrous Metals: Clean ungalvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC's recommendations.

   a. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.
   b. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat.

4. Galvanized Surfaces: Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods. Lightly etch surface if necessary to promote adhesion of paints.

D. Material Preparation: Mix and prepare paint materials according to manufacturer's written instructions.

1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.
2. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
3. Use only thinners approved by paint manufacturer and only within recommended limits.

E. Tinting: Tint each undercoat a lighter shade to simplify identification of each coat when multiple coats of same material are applied. Tint undercoats to match the color of the finish coat, but provide sufficient differences in shade of undercoats to distinguish each separate coat.

3.3 APPLICATION

A. General: Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.

1. Paint colors, surface treatments, and finishes are indicated in the paint schedules.
2. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.
3. Provide finish coats that are compatible with primers used.
4. The term "exposed surfaces" includes areas visible when permanent or built-in fixtures, grilles, convector covers, covers for finned-tube radiation, and similar components are in place. Extend coatings in these areas, as required, to maintain system integrity and provide desired protection.
5. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
6. Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.
7. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.

B. Scheduling Painting: Coordinate with COR application of paint. Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.

1. The number of coats and film thickness required are the same regardless of application method. Do not apply succeeding coats until previous coat has cured as recommended by manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.
2. Omit primer over metal surfaces that have been shop primed and touchup painted.
3. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure that edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.
4. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, and does not deform or feel sticky under moderate thumb pressure, and until application of another coat of paint does not cause undercoat to lift or lose adhesion.

C. Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.

1. Brushes: Use brushes best suited for type of material applied. Use brush of appropriate size for surface or item being painted.
2. Rollers: Use rollers of carpet, velvet-back, or high-pile sheep's wool as recommended by manufacturer for material and texture required.
3. Spray Equipment: Use airless spray equipment with orifice size as recommended by manufacturer for material and texture required. Use of spray equipment in Control Wing Basement may be restricted or prohibited. Coordinate with COR.

D. Minimum Coating Thickness: Apply paint materials no thinner than manufacturer's recommended spreading rate to achieve dry film thickness indicated. Provide total dry film thickness of the entire system as recommended by manufacturer.

E. Mechanical Work: Painting mechanical work is limited to items exposed in occupied spaces. Mechanical items to be painted include the following:

1. Metal piping where indicated. Do not paint copper and PVC.
2. Ductwork, non-insulated externally where indicated.
3. Primed equipment supports where indicated.
4. Accessory items where indicated

F. Telecommunication items to be painted include, but are not limited to the following:

1. Metal racks, which are not pre-finished and are exposed in occupied space, where indicated.

G. Fire Alarm and Sprinkler Systems.

H. Block Fillers: Apply block fillers to concrete masonry block at a rate to ensure complete coverage with pores filled.

I. Prime Coats: Before applying finish coats, apply a prime coat, as recommended by manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn-through or other defects due to insufficient sealing.

J. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.

K. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

3.4 FIELD QUALITY CONTROL

A. The FAA reserves the right to invoke the following test procedure at any time and as often as the FAA deems necessary during the period when paint is being applied:

1. The FAA will engage the services of an independent testing agency to sample the paint material being used. Samples of material delivered to the Project will be taken, identified, sealed, and certified in the presence of the Contractor.
2. The testing agency will perform appropriate tests for the following characteristics as required by the FAA:

   a. Quantitative materials analysis
   b. Abrasion resistance
   c. Apparent reflectivity

d. Flexibility
e. Washability
f. Absorption
g. Accelerated weathering
h. Dry opacity
i. Accelerated yellowness
j. Recoating
k. Skinning
l. Color retention
m. Alkali and mildew resistance

3. If test results show material being used does not comply with specified requirements, the Contractor may be directed to stop painting, remove non-complying paint, pay for testing, repaint surfaces coated with rejected paint, and remove rejected paint from previously painted surfaces if, upon repainting with specified paint, the two coatings are incompatible.

3.5 CLEANING

A. Cleanup: At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from Project site.

1. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping without scratching or damaging adjacent finished surfaces.

3.6 PROTECTION

A. Protect work of other trades, whether being painted or not, against damage from painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by COR.

B. Provide "Wet Paint" signs to protect newly painted finishes. After completing painting operations, remove temporary protective wrappings provided by others to protect their work.

1. After work of other trades is complete, touch up and restore damaged or defaced painted surfaces. Comply with procedures specified in PDCA P1.

3.7 INTERIOR PAINT SCHEDULE

A. Concrete and Masonry (Other Than Concrete Unit Masonry): Provide the following paint systems over interior concrete and brick masonry substrates:

1. Low-Luster Acrylic-Enamel Finish: Two finish coats over a primer.

a. Primer: Interior concrete and masonry primer.
b. Finish Coats: Interior low-luster acrylic enamel.

B. Concrete Unit Masonry: Provide the following finish systems over interior concrete masonry:

1. Low-Luster Acrylic-Enamel Finish: Two finish coats over a block filler.

a. Block Filler: Concrete unit masonry block filler.
b. Finish Coats: Interior low-luster acrylic enamel.

C. Gypsum Board: Provide the following finish systems over interior gypsum board surfaces:

1. Flat Acrylic Finish: Two finish coats over a primer.

a. Primer: Interior gypsum board primer.
b. Finish Coats: Interior flat acrylic paint.

2. Low-Luster Acrylic-Enamel Finish: Two finish coats over a primer.

a. Primer: Interior gypsum board primer.
b. Finish Coats: Interior low-luster acrylic enamel.

D. Plaster: Provide the following finish systems over new interior plaster surfaces:

1. Flat Acrylic Finish: Two finish coats over a primer.

a. Primer: Interior plaster primer.
b. Finish Coats: Interior flat acrylic paint.

2. Low-Luster Acrylic-Enamel Finish: Two finish coats over a primer.

a. Primer: Interior plaster primer.
b. Finish Coats: Interior low-luster acrylic enamel.

E. Wood and MBO: Provide the following paint finish systems over new interior wood surfaces:

1. Semigloss Acrylic-Enamel Finish: Two finish coats over a wood undercoater.

a. Primer: Interior wood primer for acrylic-enamel and semigloss alkyd-enamel finishes.
b. Finish Coats: Interior semigloss acrylic enamel.

F. Ferrous Metal: Provide the following finish systems over ferrous metal:

1. Semigloss Acrylic-Enamel Finish: Two finish coats over a primer.

a. Primer: Interior ferrous-metal primer.
b. Finish Coats: Interior semigloss acrylic enamel.

G. Zinc-Coated Metal: Provide the following finish systems over interior zinc-coated metal surfaces:

1. Flat Acrylic Finish: Two finish coats over a primer.

a. Primer: Interior zinc-coated metal primer.
b. Finish Coats: Interior flat acrylic paint.

H. All-Service Jacket over Insulation: Provide the following finish system on cotton or canvas insulation covering:

1. Flat Acrylic Finish: Two finish coats. Add fungicidal agent to render fabric mildew proof.

a. Finish Coats: Interior flat latex-emulsion size.

3.8 EXTERIOR PAINT SCHEDULE

A. Galvanized-Metal Substrates:

1. Semi-Gloss or Gloss Acrylic Finish. Provide two coats.

a. Primer: Direct to Metal product is self-priming.
b. Finish: Direct to Metal gloss or semi-gloss.

END OF SECTION 09 91 00

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SECTION 09 96 46 - INTUMESCENT PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes surface preparation and application of fire-retardant intumescent paint.

1.2 REFERENCES

INTERNATIONAL CODE COUNCIL (ICC)

IBC-2009..International Building Code
IFC-2009 ....International Fire Code

FAA CRITERIA

Specification section 09 91 00.............Painting

FM GLOBAL (FMG)

FM P7825..Approval Guide

MASTER PAINTER's INTERNATIONAL (MPI)

MPI #62-67, 126 ....Fire Retardant Coatings (ULC/UL Approved)
MPI Section 09900...............................MPI Architectural Painting Specification Manual

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101..Life Safety Code

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC-SP-1 ....Solvent Cleaning
SSPC-SP-2 ....Hand Tool Cleaning
SSPC-SP-3 ....Power Tool Cleaning
SSPC-SP-6 ....Commercial Blast Cleaning

UNDERWRITERS LABORATORIES INC. (ULI)

UL FPED - 2009 ....Fire Protection Equipment Directory

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's product literature for each type of Intumescent Paint to be installed. All literature must include the UL Classification mark or other qualified Listing Agency's approval. Literature must indicate product characteristics, typical uses, performance and limitation criteria, test data, and storage requirements.

B. Samples: For each intumescent paint and for each color required.

C. Material Safety Data Sheets (MSDS)

1. Submit MSDS information for each Intumescent product.

D. Installer Certification

1. Submit manufacturer's certification of the installer for said manufacturer's intumescent products.
2. Submit descriptions and contact information for at least three (3) previous projects, similar in size and type to this project.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less
2. Smoke-Developed Index: 450 or less

B. MPI Standards: Comply with indicated requirements for the following:

1. Products: MPI standards indicated and listed in "MPI Approved Products List."
2. Preparation and Workmanship: "MPI Architectural Painting Specification Manual" for products and paint systems indicated.

C. Mockups: Apply benchmark Samples of paint system indicated and of each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Wall Surfaces: Prepare Samples of at least 10 sq. ft.
2. If accepted, mockup will demonstrate minimum standard for the work. Mockup may remain as part of the work.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not store, use or install intumescent paint under environmental conditions outside manufacturer's absolute limits. Provide proper ventilation in installation areas and all areas affected by installation. Comply with recommended procedures, precautions, or remedies described in the MSDS as applicable.

Dispose of excess materials as required in the MSDS and manufacturer’s instructions. Excess materials must be disposed of off-site by the Contractor.

B. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not store, use or install intumescent paint under environmental conditions outside manufacturer’s absolute limits. Provide proper ventilation in installation areas and all areas affected by installation. Comply with recommended procedures, precautions, or remedies described in the MSDS as applicable. Dispose of excess materials as required in the MSDS and manufacturer’s instructions. Excess materials must be disposed of off-site by the Contractor.

C. Ventilate through-penetration intumescent paint per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

PART 2 - PRODUCTS

2.1 INTUMESCENT PAINT MATERIALS, GENERAL

A. Material Compatibility:

1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each material or coat, provide products and spreading rates recommended in writing by intumescent paint manufacturer for use on substrate indicated. Comply with requirements for fire-retardant coating classification and surface-burning characteristics indicated.

B. Product Approvals: All products shall be UL approved for the installed configuration.

C. Appearance and site approval: COR shall review and approve samples/mock-ups prior to installation.

1. Colors and Gloss: As selected by COR from manufacturer's full range.
2. Application: In accordance with UL approval, as selected by the COR between trowel applied and spray applied.

2.2 INTERIOR, PIGMENTED, INTUMESCENT PAINT SYSTEM

A. Primer: Intumescent paint manufacturer's recommended primer compatible with substrate and other materials indicated.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Albi Manufacturing, a division of StanChem, Inc.; Albi 490W
   b. Benjamin Moore & Co.; Fresh Start 217 Alkyd Enamel Underbody or Super Spec C245 Alkyd Enamel Undercoater/Primer Sealer.

c. Fire Research Laboratories/Ocean Fire Retardants Inc.; latex primer approved by manufacturer.
d. Flame Control Coatings, LLC; No. 3001 Primer.
e. International Fire Resistant Systems, Inc.; primer approved by manufacturer.
f. Magna Coatings Technology Inc.; SafeCoat 725 Sealer/Overcoat.
g. Muralo Company (The); Cedar Solution #2201.
h. NoFire Technologies, Inc.; primer approved by manufacturer.
i. PPG Industries, Inc.; Speed Hide 6-6 interior quick-drying enamel undercoater.

B. Fire-Retardant Intumescent Paint: Solvent-based, modified-alkyd-type, fire-retardant paint for interior wood and other combustible surfaces**;** MPI #63.

1. Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Flame Control Coatings, LLC; No. 10-10; flat finish.
b. Albi Manufacturing; a division of StanChem, Inc.; Albi-Cote 107A; flat finish.

C. Topcoat/Overcoat: Solvent-based, alkyd-type, pigmented, fire-inert, protective-finish coating that will not affect fire-retardant class of intumescent coating.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Albi Manufacturing, a division of StanChem, Inc.; Albi 144 semigloss fire-inert alkyd coating.
b. Fire Research Laboratories/Ocean Fire Retardants Inc.; TopCoat X, pigmented.
c. Flame Control Coatings, LLC; No. 30-30; semigloss finish] [No. 666A; semigloss finish.
d. International Fire Resistant Systems, Inc.; coating approved by International Fire Resistant Systems.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions where the intumescent paint is to be installed and notify the COR of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until satisfactory conditions have been achieved in a manner acceptable to the COR. Verify that all penetrating elements and supporting devices are safe and suitable for installation of firestop products.

3.2 SURFACE PREPERATION

A. Comply with manufacturer's written instructions and SSPC recommendations applicable to substrates and coating systems indicated.

B. Clean substrate of dirt, dust, grease, oil, loose material or other matter which may affect bond of fireproofing.

3.3 APPLICATION

A. Apply intumescent paints according to manufacturer's written instructions and to comply with requirements for fire-retardant coating classification.

1. Finish doors on faces with intumescent finish. Paint tops, bottoms, and side edges with fire-inert finish.

B. At completion of construction activities, touch up and restore damaged or defaced coated surfaces.

3.4 PAINT SYSTEM SCHEDULE

A. Prime Coat: If required and approved by intumescent paint manufacturer.

B. Fire-Retardant Intumescent Coating: Minimum two coats to comply with requirements for fire-retardant coating classification and surface-burning characteristics indicated.

C. Topcoat/Overcoat: Apply if required or recommended and approved by intumescent paint manufacturer.

3.5 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed using manufacturer’s guidelines.

B. Inspections will be performed to verify compliance.

C. Patch fireproofing, which has been cut away to facilitate work of other trades, so as to maintain complete coverage of full thickness on appropriate substrate.

D. Correct unacceptable work and provide further inspection to verify compliance with requirements, at no cost.

3.6 FINAL INSPECTION

A. The COR must perform inspections to verify compliance with requirements. The Contractor must correct unacceptable work and provide further inspection to verify compliance with requirements. Examine penetration seals for proper installation, adhesion and curing as may be appropriate for the respective seal materials. Keep areas of work accessible. Document completion and inspection as required.

B. Bond strength test: COR may request bond strength test after installation complete. Bond strength test results shall be in compliance with manufacturer’s recommendations, and is subject to COR approval.

C. Contractor must make arrangements with the COR for final inspection. Contractor must provide at least fifteen calendar days written notice for all tests or as otherwise specified herein. Contractor must provide written certification, 14 calendar days prior to the final inspection, that the firestop systems have been installed as follows:

1. All penetrations have been sealed with an appropriate, correctly installed, classified firestop system in accordance with its listing and the manufacturer's installation instructions. The contractor must provide a copy of the UL Listing for the types of paints utilized as well as the locations each system was installed.

D. If after being advised by the Contractor that the work is completed and ready for the inspection, the work has not been completed or the final inspection is unsatisfactory, the Contractor must be responsible for FAA's extra expenses including labor for all inspection and witnessing the re-test of the work. Such extra fees must be deducted from the payments made by FAA to the Contractor.

END OF SECTION 09 96 46

SECTION 10 21 13 - TOILET COMPARTMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solid Plastic toilet compartments configured as toilet enclosures and urinal screens.

1.2 REFERENCES

A. ASTM International (ASTM):

1. A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

1.3 SYSTEM DESCRIPTION

A. Compartment Configurations:

1. Toilet partitions: Floor mounted, overhead braced.
2. Urinal screens: Wall mounted.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For toilet compartments. Include plans, elevations, sections, details, and attachments to other work.

1. Show locations of cutouts for compartment-mounted toilet accessories.
2. Show locations of reinforcements for compartment-mounted grab bars.
3. Show locations of centerlines of toilet fixtures.
4. Show overhead support or bracing locations.

C. Sustainable Design Submittals:

1. Recycled Content: Certify percentages of post-consumer and pre-consumer recycled content.
2. Regional Materials: Certify distance between manufacturer and Project and between manufacturer and extraction or harvest point in miles.

D. Samples for Initial Selection: For each type of unit indicated. Include Samples of hardware and accessories involving material and color selection.

E. Product Certificates: For each type of toilet compartment, from manufacturer.

F. Maintenance Data: For toilet compartments to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Comply with requirements in GSA's CID-A-A-60003, "Partitions, Toilets, Complete."

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84, or another standard acceptable to authorities having jurisdiction, by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 450 or less.

C. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities" for toilet compartments designated as accessible.

1.6 WARRANTY

A. Provide manufacturer’s 25 year warranty against breakage, corrosion, and delamination under normal conditions.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of toilet fixtures, walls, columns, ceilings, and other construction contiguous with toilet compartments by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Castings: ASTM B 26/B 26M.

B. Aluminum Extrusions: ASTM B221, 6463-T5 alloy and temper.

C. Brass Castings: ASTM B 584.

D. Brass Extrusions: ASTM B 455.

E. Steel Sheet: Commercial steel sheet for exposed applications; mill phosphatized and selected for smoothness.

1. Electrolytically Zinc Coated: ASTM A 879/A 879M, 01Z.
2. Hot-Dip Galvanized: ASTM A 653/A 653M, either hot-dip galvanized or galvannealed.

F. Stainless Steel: ASTM A167, Type 304.

G. Stainless-Steel Castings: ASTM A 743/A 743M.

H. Zamac: ASTM B 86, commercial zinc-alloy die castings.

2.2 STAINLESS STEEL TOILET COMPARTMENTS

A. Toilet-Enclosure Style: Floor anchored overhead braced.

B. Entrance-Screen Style: Floor anchored overhead braced.

C. Urinal-Screen Style: Wall hung, flat panel

D. Door, Panel, and Pilaster Construction: Seamless, metal facing sheets pressure laminated to core material; with continuous, interlocking molding strip or lapped-and-formed edge closures; corners secured by welding or clips and exposed welds ground smooth. Provide with no-sightline system**.** Exposed surfaces shall be free of pitting, seam marks, roller marks, stains, discolorations, telegraphing of core material, or other imperfections.

1. Core Material: Manufacturer's standard sound-deadening honeycomb of resin-impregnated kraft paper in thickness required to provide finished thickness of 1 inch for doors and panels and 1-1/4 inches for pilasters.
2. Grab-Bar Reinforcement: Provide concealed internal reinforcement for grab bars mounted on units of size and material adequate for panel to withstand applied downward load on grab bar of at least 250 lbf , when tested according to ASTM F446, without deformation of panel.
3. Tapping Reinforcement: Provide concealed reinforcement for tapping (threading) at locations where machine screws are used for attaching items to units.

E. Urinal-Screen Construction:

1. Flat-Panel Urinal Screen: Matching panel construction.
2. Integral-Flange, Wall-Hung Urinal Screen: Similar to panel construction, with integral full-height flanges for wall attachment, and maximum 1-1/4 inches thick.
3. Wedge-Shaped, Wall-Hung Urinal Screen: Similar to panels, V-shaped, fabricated for concealed wall attachment, and maximum 6 inches wide at wall and minimum 1 inch wide at protruding end.

F. Facing Sheets and Closures: Stainless-steel sheet of nominal thicknesses as follows:

1. Pilasters, Braced at Both Ends: Manufacturer's standard thickness, but not less than 0.038 inch.

2. Pilasters, Unbraced at One End: Manufacturer's standard thickness, but not less than 0.050 inch.
3. Panels: Manufacturer's standard thickness, but not less than 0.031 inch.
4. Doors: Manufacturer's standard thickness, but not less than 0.031 inch.
5. Flat-Panel Urinal Screens: Thickness matching the panels.
6. Integral-Flange, Wall-Hung Urinal Screens: Manufacturer's standard thickness, but not less than 0.031 inch
7. Wedge-Shaped, Wall-Hung Urinal Screens: Manufacturer's standard thickness, but not less than 0.038 inch.

G. Pilaster Shoes and Sleeves (Caps): Stainless steel sheet, not less than 0.031-inch nominal thickness and 3 inches high, finished to match hardware.

H. Urinal-Screen Post: Manufacturer's standard post design of 1-3/4-inch- (44-mm-) square, aluminum tube with satin finish; with shoe and sleeve (cap) matching that on the pilaster.

I. Brackets (Fittings):

1. Stirrup Type: Ear or U-brackets; stainless steel.
2. Full-Height (Continuous) Type: Manufacturer's standard design; stainless steel.

J. Stainless Steel Finish: ASTM A480/A480M No. 4 bright, directional polish on exposed faces. Protect exposed surfaces from damage by application of strippable, temporary protective covering before shipment.

2.3 ACCESSORIES

A. Hardware and Accessories: Manufacturer's standard design, heavy-duty operating hardware and accessories.

1. Material: Stainless steel.
2. Hinges: Manufacturer's standard paired, self-closing type that can be adjusted to hold doors open at any angle up to 90 degrees.
3. Latch and Keeper: Manufacturer's standard surface-mounted latch unit designed for emergency access and with combination rubber-faced door strike and keeper. Provide units that comply with regulatory requirements for accessibility at compartments designated as accessible.
4. Coat Hook: Manufacturer's standard combination hook and rubber-tipped bumper, sized to prevent in-swinging door from hitting compartment-mounted accessories.
5. Door Bumper: Manufacturer's standard rubber-tipped bumper at out-swinging doors.
6. Door Pull: Manufacturer's standard unit at out-swinging doors that complies with regulatory requirements for accessibility. Provide units on both sides of doors at compartments designated as accessible.

B. Overhead Bracing: Manufacturer's standard continuous, extruded-aluminum head rail with antigrip profile and in manufacturer's standard finish.

C. Anchorages and Fasteners: Manufacturer's standard exposed fasteners of stainless steel or chrome-plated steel or brass, finished to match the items they are securing, with theft-resistant-type heads. Provide sex-type bolts for through-bolt applications. For concealed anchors, use stainless steel, hot-dip galvanized steel, or other rust-resistant, protective-coated steel.

2.4 FABRICATION

A. Fabrication, General: Fabricate toilet compartment components to sizes indicated. Coordinate requirements and provide cutouts for through-partition toilet accessories and solid blocking within panel where required for attachment of toilet accessories.

B. Floor-and-Ceiling-Anchored Units: Provide manufacturer's standard corrosion-resistant anchoring assemblies with leveling adjustment nuts at tops and bottoms of pilasters. Provide shoes and sleeves (caps) at pilasters to conceal anchorage.

C. Urinal-Screen Posts: Provide manufacturer's standard corrosion-resistant anchoring assemblies with leveling adjustment nuts at tops and bottoms of posts. Provide shoes and sleeves (caps) at posts to conceal anchorage.

D. Door Size and Swings: Unless otherwise indicated, provide 24-inch- wide in-swinging doors for standard toilet compartments and 36-inch- wide out-swinging doors with a minimum 32-inch-wide clear opening for compartments designated as accessible.

PART 3 - EXECUTION

3.1 ADJUSTING

A. Hardware Adjustment: Adjust and lubricate hardware according to hardware manufacturer's written instructions for proper operation. Set hinges on in-swinging doors to hold doors open approximately 30 degrees from closed position when unlatched. Set hinges on out-swinging doors to return doors to fully closed position.

3.2 INSTALLATION

A. General: Comply with manufacturer's written installation instructions. Install units’ rigid, straight, level, and plumb. Secure units in position with manufacturer's recommended anchoring devices.

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SECTION 10 28 00 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Public-use washroom accessories.
2. Underlavatory guards.
3. Custodial accessories.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include the following:

1. Construction details and dimensions.
2. Anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.
3. Material and finish descriptions.
4. Features that will be included for Project.
5. Manufacturer's warranty.

B. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.

1. Identify locations using room designations indicated on Drawings.
2. Identify products using designations indicated on Drawings.

C. Maintenance Data: For toilet and bath accessories to include in maintenance manuals.

1.3 QUALITY ASSURANCE

A. Source Limitations: For products listed together in the same articles in Part 2, provide products of same manufacturer unless otherwise approved by COTR.

1.4 COORDINATION

A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.

B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.

1.5 WARRANTY

A. Special Mirror Warranty: Manufacturer's standard form in which manufacturer agrees to replace mirrors that develop visible silver spoilage defects and that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Stainless Steel: ASTM A 666, Type 304, 0.0312-inch minimum nominal thickness, unless otherwise indicated.

B. Brass: ASTM B 19 flat products; ASTM B 16, rods, shapes, forgings, and flat products with finished edges; or ASTM B 30, castings.

C. Steel Sheet: ASTM A 1008/A 1008M, Designation CS (cold rolled, commercial steel), 0.0359-inch minimum nominal thickness.

D. Galvanized Steel Sheet: ASTM A 653/A 653M, with G60 hot-dip zinc coating.

E. Galvanized Steel Mounting Devices: ASTM A 153/A 153M, hot-dip galvanized after fabrication.

F. Fasteners: Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.

G. Chrome Plating: ASTM B 456, Service Condition Number SC 2 (moderate service).

H. Mirrors: ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

I. ABS Plastic: Acrylonitrile-butadiene-styrene resin formulation.

2.2 PUBLIC-USE WASHROOM ACCESSORIES

A. Basis-of-Design Product: The design for accessories is based on products indicated on Drawings. Subject to compliance with requirements, provide the named product or a comparable product by one of the following:

1. A & J Washroom Accessories, Inc.
2. American Specialties, Inc.
3. Bobrick Washroom Equipment, Inc.
4. Bradley Corporation.
5. General Accessory Manufacturing Co. (GAMCO).

2.3 UNDERLAVATORY GUARDS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Plumberex Specialty Products, Inc.
2. TCI Products.
3. Truebro, Inc.

B. Underlavatory Guard:
1. Description: Insulating pipe covering for supply and drain piping assemblies, that prevent direct contact with and burns from piping, and allow service access without removing coverings.
2. Material and Finish: Antimicrobial, molded-plastic, white.

2.4 FABRICATION

A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.

B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to FAA's representative.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

3.2 ADJUSTING AND CLEANING

A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.

B. Remove temporary labels and protective coatings.

C. Clean and polish exposed surfaces according to manufacturer's written recommendations.

END OF SECTION 10 28 00

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SECTION 12 36 61.16 - SOLID SURFACING COUNTERTOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Solid surface material countertops.
   Solid surface material backsplashes.

1.3 ACTION SUBMITTALS

A. Product Data: For countertop materials.

B. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.

1. Show locations and details of joints.
2. Show direction of directional pattern, if any.

C. Samples for Initial Selection: For each type of material exposed to view.

D. Samples for Verification: For the following products:

1. Countertop material, 6 inches square.
2. Wood trim, 8 inches long.
3. One full-size solid surface material countertop, with front edge and backsplash, 8 by 10 inches, of construction and in configuration specified.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For fabricator.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For solid surface material countertops to include in maintenance manuals. Include Product Data for care products used or recommended by Installer and names, addresses, and telephone numbers of local sources for products.

1.6 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom-fabricate countertops similar to that required for this Project, and whose products have a record of successful in-service performance.

B. Installer Qualifications: Fabricator of countertops.

C. Mockups: Build mockups to demonstrate aesthetic effects and to set quality standards for fabrication and execution.

1. Build mockup of typical countertop as shown on Drawings.

1.7 FIELD CONDITIONS

A. Field Measurements: Verify dimensions of countertops by field measurements after base cabinets are installed but before countertop fabrication is complete.

1.8 COORDINATION

A. Coordinate locations of utilities that will penetrate countertops or backsplashes.

PART 2 - PRODUCTS

2.1 SOLID SURFACE COUNTERTOP MATERIALS

A. Solid Surface Material: Homogeneous-filled plastic resin complying with ICPA SS-1.
1. Type: Provide Standard type unless Special Purpose type is indicated.
2. Integral Sink Bowls: Comply with CSA B45.5/IAPMO Z124.
3. Colors and Patterns: As selected by Architect from manufacturer's full range.

B. Particleboard: ANSI A208.1, Grade M-2.

C. Plywood: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.

2.2 COUNTERTOP FABRICATION

A. Fabricate countertops according to solid surface material manufacturer's written instructions and to the AWI/AWMAC/WI's "Architectural Woodwork Standards."

1. Grade: Premium.

B. Countertops: 1/2-inch- thick, solid surface material with front edge built up with same material.

C. Backsplashes: 1/2-inch- thick, solid surface material.

D. Fabricate tops with shop-applied edges unless otherwise indicated. Comply with solid surface material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.

E. Joints: Fabricate countertops in sections for joining in field.

1. Joint Locations: Not within 18 inches of a sink or cooktop and not where a countertop section less than 36 inches long would result, unless unavoidable.

F. Cutouts and Holes:

1. Undercounter Plumbing Fixtures: Make cutouts for fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.

a. Provide vertical edges, slightly eased at juncture of cutout edges with top and bottom surfaces of countertop and projecting 3/16 inch into fixture opening.

2. Counter-Mounted Plumbing Fixtures: Prepare countertops in shop for field cutting openings for counter-mounted fixtures. Mark tops for cutouts and drill holes at corners of cutout locations. Make corner holes of largest radius practical.

3. Fittings: Drill countertops in shop for plumbing fittings, undercounter soap dispensers, and similar items.

2.3 INSTALLATION MATERIALS

A. Adhesive: Product recommended by solid surface material manufacturer.

B. Sealant for Countertops: Comply with applicable requirements in Section 079200 "Joint Sealants."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates to receive solid surface material countertops and conditions under which countertops will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of countertops.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install countertops level to a tolerance of 1/8 inch in 8 feet, 1/4 inch maximum. Do not exceed 1/64-inch difference between planes of adjacent units.

B. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Predrill holes for screws as recommended by manufacturer. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.

C. Fasten subtops to cabinets by screwing through subtops into cornerblocks of base cabinets. Shim as needed to align subtops in a level plane.

D. Secure countertops to subtops with adhesive according to solid surface material manufacturer's written instructions. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.

E. Bond joints with adhesive and draw tight as countertops are set. Mask areas of countertops adjacent to joints to prevent adhesive smears.
   1. Clamp units to temporary bracing, supports, or each other to ensure that countertops are properly aligned and joints are of specified width.

F. Install backsplashes and end splashes by adhering to wall and countertops with adhesive. Mask areas of countertops and splashes adjacent to joints to prevent adhesive smears.

G. Install aprons to backing and countertops with adhesive. Mask areas of countertops and splashes adjacent to joints to prevent adhesive smears. Fasten by screwing through backing. Predrill holes for screws as recommended by manufacturer.

H. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.

   1. Seal edges of cutouts in particleboard subtops by saturating with varnish.

I. Apply sealant to gaps at walls; comply with Section 079200 "Joint Sealants."

END OF SECTION 12 36 61.16

SECTION 21 12 00 STANDPIPE SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

FM GLOBAL (FM)

FM APP GUIDE .... https://www.approvalguide.com/

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13-2016 .... Standard for the Installation of Sprinkler Systems
NFPA 14-2019 .... Standard for the Installation of Standpipes and Hose Systems

UNDERWRITERS LABORATORIES INC. (ULI)

UL FPED... http://productspec.ul.com/index.php

1.2 SYSTEM DESCRIPTION

A. Design and provide new manual dry Class I standpipe system as shown.

B. System design and manufacturer's products shall be in accordance with the required and advisory provisions of NFPA 14 except as modified herein. Each system shall include materials, accessories, and equipment inside and outside the building necessary to provide each system complete and ready for use. Devices and equipment shall be UL FPED or FM APP GUIDE approved for fire protection service. In the publications referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears. Reference to the "authority having jurisdiction" shall be interpreted to mean the FAA Contracting Officer.

C. Residual Pressure

1. The minimum residual pressure at the outlet of the most remote 2 ½-inch hose connection shall be 100 pounds per square inch while the system is discharging at the required flow rates.

D. Friction Losses

1. Calculate losses in piping in accordance with the Hazen-Williams formula with 'C' value of 120 for steel piping, 150 for copper tubing, and 140 for cement-lined ductile-iron piping.

E. Standpipe System Drawings

1. Prepare in accordance with the requirements for "Plans and Specifications" as specified in NFPA 14. Each drawing shall be 34 x 22 inches. Plans shall be drawn to a scale not less than 1/8-inch scale. Do not commence work until the design of each system and the various components have been approved. Show data essential for proper installation of each system. Show details, plan view, elevations, and sections of the systems supply and piping. Show piping schematic of systems supply, devices, valves, pipe, and fittings. Show:

    a. Room, space or area layout and include pipe supports and hangers.

1.3 SUBMITTALS

A. Government approval is required for all submittals. The FAA Contracting Officer will review and approve all submittals in this section requiring Government approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

B. Shop Drawings

1. Standpipe system

C. Product Data

1. Data which describes more than one type of item shall be clearly marked to indicate which type the Contractor intends to provide. Submit one original for each item and clear, legible, first-generation photocopies for the remainder of the specified copies. Incomplete or illegible photocopies will not be accepted. Partial submittals will not be accepted.
    a. Aboveground pipe and fittings
    b. Mechanical couplings
    c. Pipe hangers and supports
    d. Hose valves
    e. Check valves
    f. Fire department connection

D. Test Reports

1. Submit for all inspections and tests specified under paragraph entitled "Field Quality Control".

    a. Preliminary tests
    b. Acceptance tests

E. Certificates

1. Submit installers qualifications as required under paragraph entitled "Qualifications of Installer".

a. Qualifications of installer
b. System as-built drawings

1.4 QUALITY ASSURANCE

A. Qualifications of Installer

1. Prior to commencing work, submit data showing that the Contractor has successfully installed fire extinguishing standpipe systems of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having the required experience. Include the names and locations of at least two installations where the Contractor or subcontractor referred to above, has installed such systems. Indicate the type and design of each system, and certify that the system has performed satisfactorily for a period of at least 18 months.

B. Qualifications of System Technician

1. Installation drawings, shop drawings and as-built drawings shall be prepared by or under the supervision of, an individual who is experienced with the types of work specified herein, and is currently certified by the National Institute for Certification in Engineering Technologies (NICET) as an engineering technician with minimum level III certification in Automatic Sprinkler System program. Contractor shall submit data for approval showing the name and certification of all involved individuals with such qualifications at or prior to submittal of drawings.

C. System As-Built Drawings

1. Upon completion, and before final acceptance of the work, submit a complete set of as-built drawings of each system. Submit 34 x 22 inches reproducible as-built drawings on mylar film with title block similar to full size contract drawings. Furnish as-built (record) working drawings in addition to the as-built drawings required by Division 1, "General Requirements".

1.5 DELIVERY, STORAGE AND HANDLING

A. Protect stored equipment from weather, humidity and temperature variations, dirt, dust, and other contaminants.

PART 2 - PRODUCTS

2.1 ABOVEGROUND PIPING SYSTEMS

A. Provide fittings for changes in direction of piping and for connections. Make changes in piping sizes through tapered reducing pipe fittings; bushings will not be permitted. Perform welding in the shop; field welding will not be permitted.

B. Pipe and Fittings

1. Piping shall conform to NFPA 14, except as modified herein. Steel piping shall be Schedule 40. Fittings shall be welded, threaded, or grooved-end type. Plain-end fittings with mechanical couplings and fittings which use steel gripping devices to bite into the pipe when pressure is applied will not be permitted. Rubber gasketed grooved-end pipe and fittings with mechanical couplings shall be permitted in pipe sizes 1.5 inches and larger. Fittings shall be UL FPED listed or FM APP GUIDE approved for use in dry pipe sprinkler systems. Fittings, mechanical couplings, and rubber gaskets shall be supplied by the same manufacturer. Steel piping with wall thickness less than Schedule 30 shall not be threaded. Side outlet tees using rubber gasketed fittings shall not be permitted. Pipe and fittings shall be metal.

C. Pipe Hangers and Supports

1. Provide in accordance with NFPA 14.

D. Valves

1. Provide in accordance with NFPA 14. Provide valves of types approved for fire service. Hose valves shall open by counterclockwise rotation.

E. Hose Valves

1. Provide bronze hose valve with 2 ½-inch National Standard male hose threads, and 2 ½-inch NH female by 1 ½-inch IPT male reducer with cap and chain.

F. Check Valves

1. Provide check valves as required by NFPA 14.
2. Check valves shall be flanged clear opening swing-check type with flanged inspection and access cover plate for sizes 4 inches and larger.

G. Identification Signs

1. Provide in accordance with NFPA 14. Attach properly lettered and approved metal signs to each valve.

H. Pipe Sleeves

1. Provide where piping passes entirely through walls, floors, roofs, and partitions. Secure sleeves in position and location during construction. Provide sleeves of sufficient length

to pass through entire thickness of walls, floors, roofs, and partitions. Provide 1-inch minimum clearance between exterior of piping and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of pipe sleeves or core-drilled holes with UL-listed fill, void, or cavity material.

2. Sleeves in Masonry and Concrete Walls, Floors and Roofs

    a. Provide hot-dip galvanized steel, ductile-iron, or cast-iron sleeves. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth. Extend sleeves in floor slabs 3 inches above finished floors.

3. Sleeves in Partitions

    a. Provide 26 gage galvanized steel sheet.

I. Escutcheon Plates

1. Provide one-piece or split-hinge type metal plates for piping passing through walls, floors, and ceilings in both exposed and concealed spaces. Provide polished stainless steel plates or chromium plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces. Securely anchor plates in place.

J. Fire Department Connection

1. Provide connections approximately 3 feet above finish grade, of the approved two-way type with 2.5-inch National Standard female hose threads with plug, chain, and identifying fire department connection escutcheon plate.

PART 3 - EXECUTION

3.1 STANDPIPE SYSTEM INSTALLATION

A. Equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the NFPA standards referenced herein. Install piping straight and true to bear evenly on hangers and supports. Provide fittings for changes in direction of piping and for all connections. Make changes in piping sizes through standard reducing pipe fittings; do not use bushings. Cut pipe accurately and work into place without springing or forcing. Ream pipe ends and free pipe and fittings from burrs. Clean with solvent to remove all varnish and cutting oil prior to assembly. Make screw joints with PTFE tape applied to male threads only.

3.2 FIELD PAINTING

A. Field painting of fire extinguishing standpipe system shall be specified in Section 09 90 00 PAINTS AND COATINGS. Field painting requirements for "Fire Extinguishing Sprinkler Systems" shall apply.

B. Piping Labels

1. Provide permanent labels in mechanical rooms, spaced at 20-foot maximum intervals along pipe, indicating "STANDPIPE".

3.3 FLUSHING

A. Flush the piping system with potable water in accordance with NFPA 14. Continue flushing operation until water is clear, but for not less than 10 minutes.

3.4 FIELD QUALITY CONTROL

A. Prior to initial operation, inspect equipment and piping systems for compliance with drawings, specifications, and manufacturer's submittals. Perform tests in the presence of the Contracting Officer to determine conformance with the specified requirements.

B. Preliminary Tests

1. Each piping system shall be hydrostatically tested at 200 pounds per square inch in accordance with NFPA 14and shall show no leakage or reduction in gauge pressure after 2 hours. The Contractor shall conduct complete preliminary tests, which shall encompass all aspects of system operation. When tests have been completed and all necessary corrections made, submit to the Contracting Officer a signed and dated certificate, similar to that specified in NFPA 13, attesting to the satisfactory completion of all testing and stating that the system is in operating condition. Also include a written request for a formal inspection and test.

C. Formal Inspection and Tests (Acceptance Tests)

1. The Contracting Officer will witness formal tests and approve all systems before they are accepted. The system shall be considered ready for such testing only after all necessary preliminary tests have been made and all deficiencies found have been corrected to the satisfaction of the Contracting Officer and written certification to this effect is received by the FAA. Submit the request for formal inspection at least 15 working days prior to the date the inspection is to take place. Experienced technicians regularly employed by the Contractor in the installation of both the mechanical and electrical portions of such systems shall be present during the inspection and shall conduct the testing. All instruments, personnel, appliances and equipment for testing shall be furnished by the Contractor. All necessary tests encompassing all aspects of system operation shall be made including the following, and any deficiency found shall be corrected and the system retested at no cost to the Government.

a. Flow Test: Perform flow tests of each standpipe riser in accordance with NFPA 14. Affix 0-200 psi pressure gauges to the lowest hose valve and next-to-highest hose valve. Connect lined 2 ½-inch diameter fire hose with underwriter's playpipe to highest hose valve and flow at least 250 gpm for 5 minutes from standpipe to a safe location outside the building. For dry pipe system, supply system through 2 ½-inch fire hose connected to the nearest fire. Furnish hose, nozzles, and fittings required for this test.

b. Additional Tests: When deficiencies, defects, or malfunctions develop during the tests required, all further testing of the system shall be suspended until proper adjustments, corrections, or revisions have been made to assure proper performance of the system. If these revisions require more than a nominal delay, the Contracting Officer shall be notified when the additional work has been completed, to arrange a new inspection and test of the system. All tests required shall be repeated prior to final acceptance, unless directed otherwise.

END OF SECTION 21 12 00

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SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, and spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical and electronic equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates in accordance with 1.4B.2.

1.4 QUALITY ASSURANCE

A. Delete first two paragraphs below if no welding. AWS states that welding qualifications remain in effect indefinitely unless welding personnel have not welded for more than six months or there is a specific reason to question their ability.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, disconnects or starters and conduit and conductor sizes are appropriately modified at the contractor’s expense. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

D. In addition to all submittal requirements indicated in this division, the contractor shall comply with all 3D BIM requirements indicated in Specification 014010 “Contractor- Prepared Coordination Drawings.”

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
3. PVC to ABS Piping Transition: ASTM D 3138.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Known Acceptable Source:

   a. Cascade Waterworks Mfg. Co.
   b. Dresser Industries, Inc.; DMD Div.
   c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
   d. JCM Industries.
   e. Smith-Blair, Inc.
   f. Viking Johnson.

2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Known Acceptable Source:

   a. Eslon Thermoplastics.

C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Known Acceptable Source:

   a. Thompson Plastics, Inc.

D. Plastic-to-Metal Transition Unions: MSS SP-107, PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Known Acceptable Source:

a. NIBCO INC.
b. NIBCO, Inc.; Chemtrol Div.

E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve ends same size as piping to be joined, and corrosion-resistant metal band on each end.

1. Known Acceptable Source:

a. Cascade Waterworks Mfg. Co.
b. Fernco, Inc.
c. Mission Rubber Company.
d. Plastic Oddities, Inc.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Revise pressure ratings and temperatures in five paragraphs and associated subparagraphs below to suit Project or add other options for specific applications.

D. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Known Acceptable Source:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

E. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150-or 300-psig minimum working pressure as required to suit system pressures.

1. Known Acceptable Source:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.

d. Watts Industries, Inc.; Water Products Div.

F. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Known Acceptable Source:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

G. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Known Acceptable Source:

a. Calpico, Inc.
b. Lochinvar Corp.

H. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Known Acceptable Source:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Known Acceptable Source:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

B. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings. At a minimum, Coordination Drawings For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved. At a minimum, these drawings shall be submitted in plan and elevation views. Single line drawings are not acceptable:

1. Fire-suppression-water piping.
2. Domestic water piping.
3. HVAC hydronic piping.
4. Electrical Conduit.
5. HVAC Equipment and Duct.
6. Telco Conduit.
7. Fire Alarm Conduit.
8. Sanitary Sewer Piping.
9. Storm Piping.
10. Cable Tray (where applicable).
11. Structural Members.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specified otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   g. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

   a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
   b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

      1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "JOINT SEALANTS" for materials and installation.

O. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

R. Verify final equipment locations for roughing-in.

S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. PVC Nonpressure Piping: Join according to ASTM D 2855.
4. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install unions and shut-off valves as close as practical to equipment to facilitate repair or replacement of equipment.

E. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment. Fabricated equipment racks shall be fabricated rigidly and anchored securely.

C. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 220500

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SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Grout.
5. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.

B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anticorrosion coated, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

F. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

G. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Jay R. Smith Mfg Co; a division of Morris Group International.
2. Zurn Industries, LLC.

B. Description: Manufactured, Dura-coated or Duco-coated cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

B. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20 psig minimum.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Carbon steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, Use NT.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. GE Construction Sealants; Momentive Performance Materials Inc.
b. Permathane®/Acryl-R®; ITW Polymers Sealants North America.
c. Polymeric Systems, Inc.
d. Sherwin-Williams Company (The).
e. The Dow Chemical Company.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. May National Associates, Inc.; a subsidiary of Sika Corporation.

C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Smooth-On.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.

4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Use silicone sealant to seal the space around outside of stack-sleeve fittings.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. Mid-America Fittings, Inc.
6. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

2.3 FLOOR PLATES

A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping and Relocated Existing Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Chrome-Plated Piping: One-piece cast brass with polished, chrome-plated finish.
c. Insulated Piping: One-piece cast brass with polished, chrome-plated finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
f. Bare Piping in Unfinished Service Spaces: One-piece cast brass with polished, chrome-plated finish.
g. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:

a. Chrome-Plated Piping: Split-casting, stamped steel with concealed hinge with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: One-piece, floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 220518

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SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and soldered ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.5 for flanges on steel valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder-joint connections.
5. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Handlever: For quarter-turn valves smaller than NPS 3.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Apollo Flow Controls; Conbraco Industries, Inc.
   b. Crane; a Crane brand.
   c. FNW; Ferguson Enterprises, Inc.
   d. Hammond Valve.
   e. Milwaukee Valve Company.

f. NIBCO INC.
g. WATTS.
h. Zurn Industries, LLC.

2. Description:

a. Standard: MSS SP-110 or MSS-145.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Bronze or brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze ball valves, two-piece with full port and bronze or brass trim. Provide with threaded or solder-joint ends.

END OF SECTION 220523.12

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.
5. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Brady Corporation.
   b. Brimar Industries, Inc.
   c. Carlton Industries, LP.

d. Champion America.
e. Craftmark Pipe Markers.
f. Marking Services, Inc.

2. Material and Thickness: Brass, 0.032-inch; aluminum, 0.032-inch; or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: Yellow.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Carlton Industries, LP.
d. Champion America.
e. Craftmark Pipe Markers.
f. Kolbi Pipe Marker Co.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: Yellow.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: Red.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Carlton Industries, LP.
5. Champion America.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Carlton Industries, LP.
5. Champion America.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch; aluminum, 0.032-inch; or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.

2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:

1. Domestic Water Piping

a. Background: Safety green.
b. Letter Colors: White.

2. Sanitary Waste and Storm Drainage Piping:

a. Background Color: Safety black.
b. Letter Color: White.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Cold Water: 1-1/2 inches, round.
b. Hot Water: 1-1/2 inches, square.

2. Valve-Tag Colors:

a. Cold Water: Natural.
b. Hot Water: Safety green.

3. Letter Colors:

a. Cold Water: White.
b. Hot Water: White.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 220553

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SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Roof drains and rainwater leaders.
5. Supplies and drains for handicap-accessible lavatories and sinks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties, equipment connections, and access panels.
5. Detail application of field-applied jackets.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Jacket Materials for Pipe: 12 inches long by NPS 2.
3. Sheet Jacket Materials: 12 inches square.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General" and "Indoor Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Aeroflex USA.
   b. Armacell LLC.
   c. K-Flex USA.

2. Preformed Pipe Insulation: Type II, Class 1, without jacket.
3. Preformed Pipe Insulation: Type II, Class 2, with factory-applied [**ASJ**] [**ASJ-SSL**] jacket.
4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA.
b. Armacell LLC.
c. K-Flex USA.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ramco Insulation, Inc.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Foster Brand; H. B. Fuller Construction Products.

C. Flexible Elastomeric Adhesive: Solvent-based adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA.
b. Armacell LLC.
c. Foster Brand; H. B. Fuller Construction Products.
d. K-Flex USA.

2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
3. Wet Flash Point: Below 0 deg F.
4. Service Temperature Range: 40 to 200 deg F.
5. Color: Black.

D. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Mon-Eco Industries, Inc.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Knauf Insulation.
   d. Vimasco Corporation.

2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Knauf Insulation.
   d. Mon-Eco Industries, Inc.
   e. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.5 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.
   d. Pittsburgh Corning Corporation.

2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 58 to plus 176 deg F.
4. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Mon-Eco Industries, Inc.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Childers Brand; H. B. Fuller Construction Products.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.

2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.

2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

2.10 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Buckaroos, Inc.
b. Just Manufacturing.
c. McGuire Manufacturing.
d. MVG Molded Products.
e. Plumberex Specialty Products, Inc.
f. Truebro.
g. Zurn Industries, LLC.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.

   a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.

2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
6. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
7. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as that of pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless steel jackets.

3.10 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, and three locations of threaded valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 3/4 inch thick.

B. Stormwater and Overflow:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.

C. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.

D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Flexible Elastomeric: 3/4 inch thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. Painted Aluminum, Smooth: 0.016 inch thick.

D. Piping, Exposed:

1. Painted Aluminum, Smooth: 0.016 inch thick.

3.14 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 220719

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. PEX tube and fittings.
3. Piping joining materials.
4. Encasement for piping.
5. Transition fittings.
6. Dielectric fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings, piping, and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372. Include marking "NSF-pw" on piping.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

E. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

F. Copper, Brass, or Bronze Pressure-Seal-Joint Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Flow Controls; Conbraco Industries, Inc.
    b. Elkhart Products Corporation.
    c. Mueller Industries, Inc.
    d. NIBCO INC.
    e. Viega LLC.

2. Fittings: Cast-brass, cast-bronze or wrought-copper with EPDM O-ring seal in each end. Sizes NPS 2-1/2 and larger with stainless steel grip ring and EPDM O-ring seal.
3. Minimum 200-psig working-pressure rating at 250 deg F.

2.3 PEX TUBE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Apollo Flow Controls; Conbraco Industries, Inc.

2. Elkhart Products Corporation.
3. FlorHeat Company (The).
4. Heat Innovations Inc.
5. SharkBite, A Division of Reliance Worldwide Corporation.
6. Sioux Chief Manufacturing Company, Inc.
7. Uponor.
8. Vanguard Piping Systems, Inc.
9. Watts Radiant; A WATTS Brand.
10. Zurn Industries, LLC.

B. Tube Material: PEX plastic according to ASTM F 876 and ASTM F 877.

C. Fittings: ASTM F 1960, cold expansion fittings and reinforcing rings.

D. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F 876; with plastic or corrosion-resistant-metal valve for each outlet.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

F. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.

G. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

H. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.5 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105/A21.5.

B. Form: Sheet or tube.

C. Color: Black or natural.

2.6 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cascade Waterworks Mfg. Co.
b. Dresser, Inc.
c. Jay R. Smith Mfg Co; a division of Morris Group International.
d. JCM Industries, Inc.
e. Smith-Blair, Inc.
f. Viking Johnson.

D. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aquatherm.
b. Colonial Engineering, Inc.
c. NIBCO INC.
d. Spears Manufacturing Company.

2. Description:

a. CPVC or PVC four-part union.
b. Brass or stainless-steel threaded end.
c. Solvent-cement-joint or threaded plastic end.
d. Rubber O-ring.
e. Union nut.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A.Y. McDonald Mfg. Co.
b. Capitol Manufacturing Company.
c. Jomar Valve.
d. WATTS.
e. Wilkins.
f. Zurn Industries, LLC.

2. Standard: ASSE 1079.
3. Pressure Rating: 125 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Capitol Manufacturing Company.
b. Matco-Norca.
c. WATTS.
d. Wilkins.
e. Zurn Industries, LLC.

2. Standard: ASSE 1079.
3. Factory-fabricated, bolted, companion-flange assembly.
4. Pressure Rating: 125 psig minimum at 180 deg F.
5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install domestic water piping level without pitch and plumb.

G. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

K. Install piping to permit valve servicing.

L. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install PEX tubing with loop at each change of direction of more than 90 degrees.

P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

Q. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools and procedure recommended by pressure-seal-fitting manufacturer. Leave insertion marks on pipe after assembly.

G. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

H. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

I. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

J. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

K. Joint Construction for Grooved-End Steel Piping: Make joints according to AWWA C606. [**Square cut**] [**Roll**] groove ends of pipe as specified. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

L. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

M. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Piping: Join according to ASTM D 2855.

N. Joints for PEX Tubing: Join according to ASTM F 1960 for cold expansion fittings and reinforcing rings.

O. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition unions.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install hangers for copper tubing and piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install vinyl-coated hangers for PEX tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within 12 inches of each fitting.

F. Support vertical runs of copper tubing and piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs ofPEX tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
2. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.

2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

    a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
    b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Initial Flush: Flush new piping, new fixtures and parts of existing piping and fixtures that have been altered, extended, or repaired with clean, potable water until dirty water does not appear at outlet(s).
2. Disinfection: Use disinfection procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow disinfection process below:

    a. Isolate system or part thereof through valving and fill with water/chlorine solution, raising chlorine level in isolated portions to at least 50 ppm (50 mg/L). Maintain this minimum chlorine level in the system for at least 24 hours; note chlorine residual levels in the system will decrease gradually over time. Alternatively, chlorine may be raised to at least 200 ppm for a minimum of three hours. Chlorine levels should be tested on-site at a minimum of 15% of the outlets.
    b. Flush system with clean, potable water until chlorine residual level is equal to that of incoming water supply, which is approximately 1 ppm. Flush duration shall last at least 10 minutes at a minimum from each outlet.

3. Laboratory Testing: Sampling and laboratory testing shall be performed after disinfecting and flushing the new system(s) in accordance with the procedures found in FAA Order No. JO 3900.61A Drinking Water Testing at Air Traffic Organization Facilities.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:

1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.

D. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.
3. PEX tube, NPS 1 and smaller.

a. Fittings for PEX tube:
1) ASTM F 1960, cold expansion fittings and reinforcing rings.
2) ASSE 1061, push-fit fittings.

E. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.

4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116

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SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Balancing valves.
2. Temperature-actuated, water mixing valves.
3. Water-hammer arresters.
4. Flexible connectors.

1.3 DEFINITIONS

A. AMI: Advanced Metering Infrastructure.

B. FKM: A family of fluroelastomer materials defined by ASTM D1418.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Test and inspection reports.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 BALANCING VALVES

A. Memory-Stop Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Crane; a Crane brand.
c. Hammond Valve.
d. Jenkins Valves; a Crane brand.
e. Milwaukee Valve Company.
f. NIBCO INC.

2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass or stainless steel.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.4 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Acorn Engineering Company; a Division of Morris Group International.

b. Apollo Flow Controls; Conbraco Industries, Inc.
c. Cash Acme, A Division of Reliance Worldwide Corporation.
d. POWERS; A WATTS Brand.
e. Symmons Industries, Inc.
f. TACO Comfort Solutions, Inc.
g. Zurn Industries, LLC.

2. Standard: ASSE 1070.
3. Pressure Rating: 125 psig.
4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 110 deg F.
9. Tempered-Water Design Flow Rate: 0.5 gpm.
10. Valve Finish: Chrome plated.

2.5 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters, WHA:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AMTROL, Inc.
b. Jay R. Smith Mfg Co; a division of Morris Group International.
c. Josam Company.
d. MIFAB, Inc.
e. Sioux Chief Manufacturing Company, Inc.
f. WATTS.
g. Zurn Industries, LLC.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.6 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flex-Hose Co., Inc.
2. Mason Industries, Inc.
3. Metraflex Company (The).

B. Stainless Steel-Hose Flexible Connectors: Corrugated-stainless steel tubing with stainless steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

A. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.

B. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

C. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201 and with contract documents.

3.2 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

3.3 CONTROL CONNECTIONS

A. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.4 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Balancing valves.
2. Temperature-actuated, water mixing valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 ADJUSTING

A. Set field-adjustable flow set points of balancing valves.

B. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 221119

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SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hubless, cast-iron soil pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe fittings.
4. Encasement for underground metal piping.

B. Related Requirements:

1. Section 221313 "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

1.6 WARRANTY

A. Listed manufacturers to provide labeling and warranty of their respective products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.
2. Waste, Force-Main Piping: 50 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. NewAge Casting.
4. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings: ASTM A 888 or CISPI 301.

C. CISPI, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ANACO-Husky.
b. Charlotte Pipe and Foundry Company.
c. Ideal Clamp Products, Inc.
d. Josam Company.
e. MIFAB, Inc.
f. Mission Rubber Company, LLC; a division of MCP Industries.
g. Tyler Pipe; a subsidiary of McWane Inc.

2. Standards: ASTM C 1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 PVC PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

E. Solvent Cement: ASTM D 2564.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Unshielded, Nonpressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Dallas Specialty & Mfg. Co.
2) Fernco Inc.
3) Froet Industries LLC.
4) Mission Rubber Company, LLC; a division of MCP Industries.
5) Plastic Oddities.

b. Standard: ASTM C 1173.
c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. End Connections: Same size as and compatible with pipes to be joined.
e. Sleeve Materials:

1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Dielectric Fittings:

1. Dielectric Unions:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) A.Y. McDonald Mfg. Co.
2) Capitol Manufacturing Company.
3) HART Industrial Unions, LLC.
4) Jomar Valve.
5) WATTS.
6) Wilkins.
7) Zurn Industries, LLC.

b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 125 psig minimum at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

2. Dielectric Flanges:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Capitol Manufacturing Company.
2) Central Plastics Company.
3) Matco-Norca.
4) WATTS.
5) Wilkins.
6) Zurn Industries, LLC.

b. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 125 psig minimum at 180 deg F.

4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

3. Dielectric-Flange Insulating Kits:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Advance Products & Systems, Inc.
2) Calpico, Inc.
3) Central Plastics Company.
4) Pipeline Seal and Insulator, Inc.

b. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig.
3) Gasket: Neoprene or phenolic.
4) Bolt Sleeves: Phenolic or polyethylene.
5) Washers: Phenolic with steel backing washers.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

   a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

   a. Reducing size of waste piping in direction of flow is prohibited.

L. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 to NPS 6; 0.5 percent downward in direction of flow for piping larger than NPS 6.
2. Horizontal Sanitary Waste Piping: See Building Sanitary Waste.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

O. Install steel piping according to applicable plumbing code.

P. Install aboveground PVC piping according to ASTM D 2665.

Q. Install underground PVC piping according to ASTM D 2321.

R. Install underground, ductile-iron, force-main piping according to AWWA C600.

1. Install buried piping inside building between wall and floor penetrations and connection to sanitary sewer piping outside building with restrained joints.
2. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.

S. Install force mains at elevations indicated.

T. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

   a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
   b. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."

2. Install drains in sanitary waste gravity-flow piping.

   a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

U. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

V. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

1. Cut threads full and clean using sharp dies.
2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

    a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
    b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
    c. Do not use pipe sections that have cracked or open welds.

C. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

D. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

E. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Unshielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:

    a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
    b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install fiberglass pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install hangers for cast-iron soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

F. Support vertical runs of cast iron soil piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs of PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.

4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
6. Equipment: Connect waste piping as indicated.

   a. Provide shutoff valve if indicated and union for each connection.
   b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:

1. Sanitary Sewer: To exterior force main.
2. Sewage Pump: To sewage pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

   a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

   a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

   a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
   b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
   c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

   a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
   b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
   c. Air pressure must remain constant without introducing additional air throughout period of inspection.
   d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.

   a. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.

   a. Isolate test source and allow to stand for four hours.
   b. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.9 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.10 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 6 and smaller shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

C. Aboveground, vent piping NPS 4 and smaller shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

D. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI cast-iron hubless-piping couplings; and coupled joints.
2. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

E. Underground sanitary-sewage force mains NPS 4 and smaller shall be any of the following:

1. Ductile-iron, push-on-joint piping and push-on joints.
2. Ductile-iron, grooved-joint piping and grooved joints.
3. Fitting-type transition coupling for piping smaller than NPS 1-1/2 and pressure transition coupling for NPS 1-1/2 and larger if dissimilar pipe materials.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cleanouts.
2. Miscellaneous sanitary drainage piping specialties.

B. Related Requirements:

1. Section 076200 "Sheet Metal Flashing and Trim" for metal roof flashing assemblies.
2. Section 077200 "Roof Accessories" for preformed flashings.
3. Section 078413 "Penetration Firestopping" for through-penetration firestop assemblies.
4. Section 221423 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.3 DEFINITIONS

A. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts, CO:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Jay R. Smith Mfg Co; a division of Morris Group International.
   b. Josam Company.
   c. MIFAB, Inc.
   d. Tyler Pipe; a subsidiary of McWane Inc.
   e. WATTS.
   f. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, cast-iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts, FCO:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Jay R. Smith Mfg Co; a division of Morris Group International.
   b. Josam Company.
   c. MIFAB, Inc.
   d. Sioux Chief Manufacturing Company, Inc.
   e. WATTS.
   f. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Threaded.
8. Closure: Cast-iron plug.

9. Adjustable Housing Material: Cast iron with setscrews or other device.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top-Loading Classification: Heavy Duty.
13. Riser: ASTM A74, Service Class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts, WCO:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Jay R. Smith Mfg Co; a division of Morris Group International.
   b. Josam Company.
   c. MIFAB, Inc.
   d. WATTS.
   e. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure Plug:

   a. Cast iron.
   b. Countersunk or raised head.
   c. Drilled and threaded for cover attachment screw.
   d. Size: Same as or not more than one size smaller than cleanout size.

6. Wall Access, Cover Plate: Round, deep, chrome-plated bronze cover plate with screw.
7. Wall Access, Frame and Cover: Round, nickel-bronze, copper-alloy, or stainless steel wall-installation frame and cover.

2.3 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Floor-Drain, Inline Trap Seal:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Jay R. Smith Mfg Co; a division of Morris Group International.
   b. Josam Company.
   c. MIFAB, Inc.
   d. RectorSeal Plumbing; A CSW Industrials Company.

2. Description: Inline floor drain trap seal, forming a physical barrier to slow trap evaporation while not impeding flow from drain.
3. Material: Polymer.
4. Standard: Tested and certified in accordance with ASSE 1072.
5. Listing: ICC-ES or IAPMO listed.
6. Size: Same as floor drain outlet or strainer throat.

B. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

C. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

D. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

E. Expansion Joints:

1. Standard: ASME A112.6.4.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install fixture air-admittance valves on fixture drain piping.

E. Install stack air-admittance valves at top of stack vent and vent stack piping.

F. Install deep-seal traps on floor drains and other waste outlets, if indicated.

G. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Size: Same as floor drain inlet.

H. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

I. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

J. Install vent caps on each vent pipe passing through roof.

K. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

L. Install wood-blocking reinforcement for wall-mounting-type specialties.

M. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, to allow service and maintenance.

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

1. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

SECTION 221319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Floor drains.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene styrene.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene.

D. PE: Polyethylene.

E. PP: Polypropylene.

F. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains, FD-1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Commercial Enameling Company.
    b. Jay R. Smith Mfg Co; a division of Morris Group International.
    c. MIFAB, Inc.
    d. Prier Products, Inc.
    e. WATTS.
    f. Zurn Industries, LLC.

2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
9. Backwater Valve: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Not required.
11. Sediment Bucket: Not required.
12. Top or Strainer Material: Nickel bronze.
13. Top of Body and Strainer Finish: Nickel bronze.
14. Top Shape: Round.
15. Top Loading Classification: Heavy Duty.
16. Funnel: Not required.
17. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
18. Trap Material: Cast iron.
19. Trap Pattern: Standard P-trap.
20. Trap Features: Trap-seal primer valve drain connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:

    a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.

c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.

a. Maintain integrity of waterproof membranes where penetrated.

5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

B. Install trench drains at low points of surface areas to be drained.

1. Set grates of drains flush with finished surface, unless otherwise indicated.

C. Comply with ASME A112.3.1 for installation of stainless-steel channel drainage systems.

1. Install on support devices, so that top will be flush with adjacent surface.

D. Install FRP channel drainage system components on support devices, so that top will be flush with adjacent surface.

E. Install plastic channel drainage system components on support devices, so that top will be flush with adjacent surface.

F. Install open drain fittings with top of hub 1 inch above floor.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Install piping adjacent to equipment to allow service and maintenance.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal roof drains.
2. Cleanouts.

B. Related Requirements:

1. Section 076200 "Sheet Metal Flashing and Trim" for penetrations of roofs.
2. Section 078413 "Penetration Firestopping" for firestopping roof penetrations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains, RD:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Jay R. Smith Mfg Co; a division of Morris Group International.
   b. Josam Company.
   c. Marathon Roofing Products.
   d. MIFAB, Inc.
   e. Sioux Chief Manufacturing Company, Inc.

f. Wade; a subsidiary of McWane Inc.
g. WATTS.
h. Zurn Industries, LLC.

2. Standard: ASME A112.6.4.
3. Body Material: Cast iron.
4. Dimension of Body: Nominal 14-to 16-inch diameter.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Flow-Control Weirs: Not required.
7. Outlet: Bottom.
8. Outlet Type: No hub.
9. Extension Collars: Required.
10. Underdeck Clamp: Required.
11. Expansion Joint: Required.
12. Sump Receiver Plate: Required.
13. Dome Material: Cast iron.
14. Perforated Gravel Guard: Not required.
15. Vandal-Proof Dome: Not required.
16. Water Dam: Not required.

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts, CO:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg Co; a division of Morris Group International.
b. Josam Company.
c. MIFAB, Inc.
d. Tyler Pipe; a subsidiary of McWane Inc.
e. Wade; a subsidiary of McWane Inc.
f. WATTS.
g. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M.
3. Size: Same as connected branch.
4. Body Material: No-hub, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, cast-iron plug.
6. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

B. Test Tees:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg Co; a division of Morris Group International.
b. Josam Company.
c. MIFAB, Inc.
d. Tyler Pipe; a subsidiary of McWane Inc.

e. WATTS.
f. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk or raised head, brass.
6. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate cleanouts at base of each vertical storm piping conductor.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install test tees in vertical conductors and near floor.

G. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

H. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Wall-mounted water closets.
2. Flushometer valves.
3. Toilet seats.
4. Supports.

1.3 DEFINITIONS

A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.

B. Remote Water Closet: Located more than 30 feet from other drain line connections or fixture and where less than 1.5 drainage fixture units are upstream of the drain line connection.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED WATER CLOSETS

A. Water Closets, Wall Mounted, Top Spud, WC-1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advanced Modern Technologies Corporation - AMTC.
b. American Standard.
c. Briggs Company (The).
d. Gerber Plumbing Fixtures LLC.
e. Kohler Co.
f. Peerless Pottery Sales, Inc.
g. Sloan Valve Company.
h. Zurn Industries, LLC.

2. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: Standard.
f. Rim Contour: Elongated.
g. Water Consumption: 1.28 gal. per flush.
h. Spud Size and Location: NPS 1-1/2; top.

3. Flushometer Valve: FV-1 or FV-2.
4. Toilet Seat: TS-1.
5. Support: Water closet carrier.
6. Water-Closet Mounting Height: Standard.

B. Water Closets, Wall Mounted, Top Spud, Accessible, WC-1A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advanced Modern Technologies Corporation - AMTC.
b. American Standard.
c. Briggs Company (The).
d. Gerber Plumbing Fixtures LLC.
e. Kohler Co.
f. Peerless Pottery Sales, Inc.
g. Sloan Valve Company.

h. Zurn Industries, LLC.

2. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: Standard.
f. Rim Contour: Elongated.
g. Water Consumption: 1.28 gal. per flush.
h. Spud Size and Location: NPS 1-1/2; top.

3. Flushometer Valve: FV-1 or FV-2.
4. Toilet Seat: TS-1.
5. Support: Water closet carrier.
6. Water-Closet Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

2.2 FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves, FV-1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advanced Modern Technologies Corporation - AMTC.
b. Delany Products.
c. Gerber Plumbing Fixtures LLC.
d. Sloan Valve Company.
e. Zurn Industries, LLC.

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig.
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed.
9. Consumption: 1.28 gal. per flush.
10. Minimum Inlet: NPS 1.
11. Minimum Outlet: NPS 1-1/4.

B. Lever-Handle, Piston Flushometer Valves, FV-2:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. Delany Products.
c. Kohler Co.

d. Sloan Valve Company.
e. TOTO USA, INC.
f. Zurn Industries, LLC.

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig.
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed.
9. Consumption: 1.28 gal. per flush.
10. Minimum Inlet: NPS 1.
11. Minimum Outlet: NPS 1-1/4.

2.3 TOILET SEATS

A. Toilet Seats, TS-1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. Bemis Manufacturing Company.
c. Centoco Manufacturing Corporation.
d. Olsonite Seat Co.
e. Sanderson Plumbing Products, Inc.
f. Sperzel of Lexington.
g. TOTO USA, INC.
h. Zurn Industries, LLC.

2. Standard: IAPMO/ANSI Z124.5.
3. Material: Plastic.
4. Type: Commercial (Standard).
5. Shape: Elongated rim, open front.
6. Hinge: Self-sustaining, check.
7. Hinge Material: Noncorroding metal.
8. Seat Cover: Required.
9. Color: White.

2.4 SUPPORTS

A. Water Closet Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Josam Company.
b. Zurn Industries, LLC.

2. Standard: ASME A112.6.1M.
3. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations that are easy for people with disabilities to reach.
5. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224213.16 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Wall-hung urinals.
2. Urinal flushometer valves.
3. Supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for urinals.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than one of each type.

PART 2 - PRODUCTS

2.1 WALL-HUNG URINALS

A. Urinals, Wall Hung, Back Outlet, Blowout, UR-1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. Kohler Co.

2. Fixture:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Strainer or Trapway: Open trapway with integral trap.
d. Water Consumption: Water saving.
e. Spud Size and Location: NPS 1-1/4; top.
f. Outlet Size and Location: NPS 2; back.
g. Color: White.

3. Flushometer Valve: FV-1.
4. Waste Fitting:

a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
b. Size: NPS 2.

5. Support: Type I Urinal Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights..
6. Urinal Mounting Height: Standard.

2.2 URINAL FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves, FV-1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advanced Modern Technologies Corporation - AMTC.
b. American Standard.
c. Delany Products.
d. Gerber Plumbing Fixtures LLC.
e. Sloan Valve Company.
f. Zurn Industries, LLC.

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig.
4. Features: Include integral check stop and backflow-prevention device.

5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Concealed.
9. Consumption: 0.125 gal. per flush.
10. Minimum Inlet: NPS 3/4.
11. Minimum Outlet: NPS 1-1/4.

2.3 SUPPORTS

A. Type I Urinal Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Jay R. Smith Mfg Co; a division of Morris Group International.
    b. Josam Company.
    c. MIFAB, Inc.
    d. Wade Drains.
    e. WATTS.
    f. Zurn Industries, LLC.
2. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.

B. Examine walls and floors for suitable conditions where urinals will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.
5. Install trap-seal liquid in waterless urinals.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
4. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed urinals and fittings.

C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

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SECTION 224216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Lavatories.
2. Faucets.
3. Supply fittings.
4. Waste fittings.
5. Supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Servicing and adjustments of automatic faucets.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, COUNTER-MOUNTED LAVATORIES

A. Lavatory, L-1: Oval, self-rimming, vitreous china, counter-mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. American Standard.
   b. Briggs Plumbing Products, Inc.
   c. Crane Plumbing, L.L.C.
   d. FNW; Ferguson Enterprises, Inc.
   e. Kohler Co.
   f. Mansfield Plumbing Products LLC.
   g. Peerless Pottery Sales, Inc.
   h. Zurn Industries, LLC.

2. Fixture:

   a. Standard: ASME A112.19.2/CSA B45.1.
   b. Type: Self-rimming for above-counter mounting.
   c. Nominal Size: Oval, 19 by 17 inches.
   d. Faucet-Hole Punching: Three holes, 2-inch centers.
   e. Faucet-Hole Location: Top.
   f. Color: White.
   g. Mounting Material: Sealant.

3. Faucet: F-1.

2.2 ENAMELED, CAST-IRON, WALL-MOUNTED LAVATORIES

A. Lavatory, L-2: Rectangular, enameled, cast iron, wall-mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. American Standard.

b. Kohler Co.
c. Zurn Industries, LLC.

2. Fixture:

a. Standard: ASME A112.19.1/CSA B45.2.
b. Type: Straight-front apron with straight back.
c. Nominal Size: Rectangular, 19 by 17 inches.
d. Faucet-Hole Punching: Three holes, 2-inch centers.
e. Faucet-Hole Location: Top.
f. Color: White.
g. Mounting Material: Wall bracket.

3. Faucet: F-1.
4. Support: Type III lavatory carrier.
5. Lavatory Mounting Height: Standard.

B. Lavatory, L-3: Rectangular, enameled, cast iron, wall-mounted, accesible.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. Kohler Co.
c. Zurn Industries, LLC.

2. Fixture:

a. Standard: ASME A112.19.1/CSA B45.2.
b. Type: Straight-front apron with straight back.
c. Nominal Size: Rectangular, 19 by 17 inches.
d. Faucet-Hole Punching: Three holes, 2-inch centers.
e. Faucet-Hole Location: Top.
f. Color: White.
g. Mounting Material: Wall bracket.

3. Faucet: F-1.
4. Support: Type III lavatory carrier.
5. Lavatory Mounting Height: Handicapped/elderly according to ICC A117.1.

2.3 SOLID-BRASS, MANUALLY OPERATED FAUCETS

A. NSF Standard: Comply with NSF 372 for faucet materials that will be in contact with potable water.

B. Lavatory Faucets, F-1: Manual-type, two-handle mixing, commercial, solid-brass valve.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. CHG; Component Hardware Group, Inc.
c. Chicago Faucets; Geberit Company.
d. Delta Faucet Company.
e. GROHE America, Inc.
f. Kohler Co.
g. Speakman Company.
h. T&S Brass and Bronze Works, Inc.
i. Zurn Industries, LLC.

2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
4. Body Type: Widespread.
5. Body Material: Commercial, solid brass.
6. Finish: Polished chrome plate.
7. Maximum Flow Rate: 0.5 gpm.
8. Mounting Type: Deck, exposed.
9. Valve Handle(s): Wrist blade, 4 inches.
10. Spout: Swivel, gooseneck type.
11. Spout Outlet: Laminar flow.
12. Operation: Compression, manual.
13. Drain: Not part of faucet.

2.4 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

A. NSF Standard: Comply with NSF 372 for faucet-spout-outlet materials that will be in contact with potable water.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AM Conservation Group, Inc.
2. Chronomite Laboratories, Inc; a division of Morris Group International.
3. NEOPERL, Inc.
4. T&S Brass and Bronze Works, Inc.

C. Description: Chrome-plated-brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.5 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 372 for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Wheel handle.

F. Risers:

1. NPS 3/8.
2. ASME A112.18.6, braided- or corrugated-stainless-steel, flexible hose riser.

2.6 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2 by NPS 1-1/4.
2. Material: Chrome-plated, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.

2.7 SUPPORTS

A. Type III Lavatory Carrier:

1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.

B. Examine counters and walls for suitable conditions where lavatories will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install lavatories level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. HVAC demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

B. General: Work shall be performed in accordance with these specifications and good practice. No modifications to these specifications will be accepted without the expressed written approval of the COTR. It is the Contractor's responsibility to document COTR's approval of any such modifications prior to the execution of work. Requirements of these Specifications modified by any addenda, change orders, written approvals and written instructions issued by the COTR, if any, shall be as specifically identified by Section and Paragraph in those addenda, change orders, written approvals and written instructions. Approvals of submittals are subject to additional limitations described elsewhere in these Specifications. System concept drawing sheets are for information only to show potential system arrangement. Field verify information contained on these drawings and is responsible for design and installation of the system in accordance with the specifications. The bid drawings do not show all information necessary for installation of the system, but are intended to be used as a guide for the purpose of designing the systems and preparing a bid.

C. Removal of Debris and Salvage: Remove rubbish and debris resulting from work on a daily basis. Debris shall be disposed of offsite. Rubbish not removed by the Contractor will be removed by the FAA and back-charged to the Contractor. Removal of debris and rubbish from the premises shall be coordinated with the COTR.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31, "Building Services Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 08 31 13 "Access Doors and Frames."

D. In addition to all submittal requirements indicated in this division, the contractor shall comply with all 3D BIM requirements indicated in Specification 01 40 10 “Contractor- Prepared Coordination Drawings.”

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:
1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Known Acceptable Source:

a. Eslon Thermoplastics.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Known Acceptable Source:

a. Thompson Plastics, Inc.

C. Plastic-to-Metal Transition Unions: MSS SP-107, PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Known Acceptable Source:

a. NIBCO INC.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Known Acceptable Source:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Known Acceptable Source:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Known Acceptable Source:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Known Acceptable Source:

a. Calpico, Inc.
b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Known Acceptable Source:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Known Acceptable Source:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

D. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to FAA.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw or spring clips.
j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:

a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
g. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge and set screw or spring clips.
i. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

    a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
    c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Section 07 62 00 "Sheet Metal Flashing and Trim" for flashing.

        1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07 92 00 "Joint Sealants" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 84 13 "Penetration Firestopping" for materials.

T. Verify final equipment locations for roughing-in.

U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Nonpressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Section 09 91 00 "Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03 30 00 "Cast-in-Place Concrete."

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 05 50 00 "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.9 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 23 05 00

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SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphaser, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply wit NEMA MG-10 Energy Management Guide for Selection and use of Polyphase Motors.

D. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 05 13

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SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.

B. Shop Drawings: Signed and sealed by a qualified Licensed Professional Engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.

3. Pipe stands. Include Product Data for components.
4. Equipment supports.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.3, "Structural Welding Code--Sheet Steel."
3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Known Acceptable Source:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Grinnell Corp.
3. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Known Acceptable Source:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Power-Strut Div.; Tyco International, Ltd.
3. Tolco Inc.
4. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Known Acceptable Source:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Known Acceptable Source:

a. B-Line Systems, Inc.; a division of Cooper Industries.
b. Hilti, Inc.
c. ITW Ramset/Red Head.

2.7 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Manufacturers:

a. ERICO/Michigan Hanger Co.
b. MIRO Industries.
c. Approved Equal.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:

a. MIRO Industries.
b. Approved Equal.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Manufacturers:

a. ERICO/Michigan Hanger Co.
b. MIRO Industries.
c. Portable Pipe Hangers.
d. Approved Equal.

2. Base: Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:

a. Portable Pipe Hangers.
b. Approved Equal.

2. Bases: One or more plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
8. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
9. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
10. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
11. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
12. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
13. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
14. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
15. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Section 07 72 00 "Roof Accessories" for curbs.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to maximum of 1 inch. Cover ends of support rods and other sharp edges with padding where sharp edges are hazard to operating personnel.

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 05 29

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SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Restrained elastomeric isolation mounts.
3. Restrained spring isolators.
4. Housed spring mounts.
5. Elastomeric hangers.
6. Spring hangers.
7. Spring hangers with vertical-limit stops.
8. Pipe riser resilient supports.
9. Resilient pipe guides.
10. Seismic snubbers.
11. Restraining braces and cables.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.3 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 120 mph
2. Building Classification Category: IV.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Assigned Seismic Use Group or Building Category as Defined in ASCE 7-2005: IV.
   a. Component Importance Factor: 1.5.
   b. Component Response Modification Factor: Per ASCE 7-2010 Table 13.6-1.

c. Component Amplification Factor: Per ASCE 7-2010 Table 13.6-1.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.221g.
4. Design Spectral Response Acceleration at 1-Second Period: 0.169g.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES or OSHPD.
   b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Licensed Professional Engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and wind forces required to select vibration isolators, seismic and wind restraints, and for designing vibration isolation bases.

   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Duct Supports: Refer to Division 23 Section, “Metal Ducts” for additional requirements.
4. Seismic- and Wind-Restraint Details:

   a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing’s. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES or OSHPD, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For Licensed Professional Engineer.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Kinetics Noise Control.
2. Mason Industries.
3. Vibration Mountings & Controls, Inc.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

H. Elastomeric Hangers Insert drawing designation: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

I. Spring Hangers Insert drawing designation: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop Insert drawing designation: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.
1.

2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

A. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

    a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.

b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

   a. Resilient Material: Oil- and water-resistant standard neoprene.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.3 SEISMIC-RESTRAINT DEVICES

A. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Hilti, Inc.
3. Kinetics Noise Control.
4. Mason Industries.
5. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES or OSHPD.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Restraint Cables: ASTM A 603 galvanized -steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

F. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

G. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

J. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES or OSHPD.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or OSHPD providing required submittals for component.

B. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

C. Ductwork Restraints:

1. Refer to Section 23 31 13 “Metal Ducts “for additional requirements.

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or OSHPD providing required submittals for component.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 23 21 13 "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing person acceptable to COR.
2. Schedule test with COR before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain COR's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by COR.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train FAA's maintenance personnel to adjust, operate, and maintain air-mounting systems.

END OF SECTION 23 05 48

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SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

1.3 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White Yellow.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Fiberboard or metal.
2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule: Provide colors per ANSI/ASME A13.1.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

   a. Chilled Water: 1-1/2 inches, round.
   b. Condenser Water: 1-1/2 inches, round.
   c. Refrigerant: 1-1/2 inches, round.
   d. Hot Water: 1-1/2 inches 2 inches, round.
   e. Gas: 1-1/2 inches, round.
   f. Low-Pressure Steam: 1-1/2 inches, round.
   g. Steam Condensate: 1-1/2 inches, round.

2. Valve-Tag Color:

   a. Chilled Water: Green.
   b. Condenser Water: Green.
   c. Refrigerant: Natural.
   d. Hot Water: Natural.
   e. Gas: Yellow.
   f. Low-Pressure Steam: Natural.
   g. Steam Condensate: Natural.

3. Letter Color:

   a. Chilled Water: White.
   b. Condenser Water: White.
   c. Refrigerant: White.
   d. Hot Water: White.
   e. Gas: White.
   f. Low-Pressure Steam: White.
   g. Steam Condensate: White.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 05 53

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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

    a. Constant-volume air systems.
    b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Variable-flow hydronic systems.
    c. Primary-secondary hydronic systems.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.3 SUBMITTALS

A. Qualification Data: Within 45 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 45 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.4 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC NEBB or TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC NEBB or TABB as a TAB technician.

B. TAB Conference: Meet with COTR and Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Coordination and cooperation of trades and subcontractors.
d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by COTR and Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.5 PROJECT CONDITIONS

A. Full FAA Occupancy: FAA will occupy the site and existing building during entire TAB period. Cooperate with FAA during TAB operations to minimize conflicts with FAA's operations.

B. Partial FAA Occupancy: FAA may occupy completed areas of building before Substantial Completion. Cooperate with FAA during TAB operations to minimize conflicts with FAA's operations.

1.6 COORDINATION

A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 23 31 13 "Metal Ducts " and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111 NEBB's "Procedural

Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 00 "HVAC Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from COTR and Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Re-measure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

3.7 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.
1. .
2. Measure flow through bypass.

3.8 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.10 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent or minus 10 percent.
2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent.
3. Heating-Water Flow Rate: Plus 10 percent or minus 5 percent.
4. Cooling-Water Flow Rate: 0 to Plus 10 percent.

3.11 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. COTR's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.

d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.

c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Air flow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Air flow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated air flow rate in cfm.
h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Air velocity in fpm.
c. Preliminary air flow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final air flow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

3. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

L. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.13 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by COTR and Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of COTR and Commissioning Authority.
3. COTR and Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, FAA may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:

    a. Calcium silicate.
    b. Cellular glass.
    c. Flexible elastomeric.
    d. Mineral fiber.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied fabric-reinforcing mesh.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.
14. Corner angles.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

8. Detail field application for each equipment type.

C. Qualification Data: For qualified Installer.

D. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Thermal Resistance Properties: Insulation and related materials shall be installed such that the minimum Thermal Resistance (R-value) of the insulation is installed to meet the requirements of ASHRAE 90.1-2007, for the applicable duct or pipe system and compatible with the operating temperatures of the system.

C. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Calcium Silicate:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Industrial Insulation Group (The); Thermo-12 Gold.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Cell-U-Foam Corporation; Ultra-CUF.
    b. Pittsburgh Corning Corporation; Foamglas Super K.

2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type II with factory-applied vinyl jacket, Type III with factory-applied FSK jacket, or Type III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Duct Wrap.
   d. Owens Corning; All-Service Duct Wrap.

H. Insulation integral to double-wall duct assemblies.

1. See specification 23 31 13 “Metal Ducts” for requirements of double-wall duct.

2. Insulation integral to double-wall duct shall have minimum thermal resistance of R-4. Insulation may be fibrous blanket type or injected foam type. Insulation shall not be exposed to the air stream inside of the duct.

3. Insulation integral to double-wall duct shall be compatible with operating temperatures of the system served, including a minimum of 20ºF above and below the operating and ambient temperatures.

I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ or with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ or with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; Commercial Board.
b. Johns Manville; 800 Series Spin-Glas.
c. Knauf Insulation; Insulation Board.
d. Owens Corning; Fiberglas 700 Series.

J. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Johns Manville; Micro-Lok.
b. Knauf Insulation; 1000 Pipe Insulation.
c. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Knauf Insulation; Permawick Pipe Insulation.
b. Owens Corning; VaporWick Pipe Insulation.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ or FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; FlameChek.
b. Johns Manville; Firetemp Wrap.
c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
d. Thermal Ceramics; FireMaster Duct Wrap.
e. 3M; Fire Barrier Wrap Products.
f. Unifrax Corporation; FyreWrap.
g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.

2.3 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Insulco, Division of MFS, Inc.; Triple I.
b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Insulco, Division of MFS, Inc.; SmoothKote.
b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
c. Rock Wool Manufacturing Company; Delta One Shot.

2.4 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-97.
b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
c. Marathon Industries, Inc.; 290.
d. Mon-Eco Industries, Inc.; 22-30.
e. Vimasco Corporation; 760.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.
c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Dow Chemical Company (The); 739, Dow Silicone.
    b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. P.I.C. Plastics, Inc.; Welding Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-35.
    b. Foster Products Corporation, H. B. Fuller Company; 30-90.
    c. ITW TACC, Division of Illinois Tool Works; CB-50.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; Encacel.
    b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
    c. Marathon Industries, Inc.; 570.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-10.
    b. Foster Products Corporation, H. B. Fuller Company; 35-00.
    c. ITW TACC, Division of Illinois Tool Works; CB-05/15.

2. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F.
4. Solids Content: 63 percent by volume and 73 percent by weight.
5. Color: White.

2.6 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-52.
    b. Foster Products Corporation, H. B. Fuller Company; 81-42.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 deg F.
5. Color: White.

2.7 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-76.
    b. Foster Products Corporation, H. B. Fuller Company; 30-45.
    c. Pittsburgh Corning Corporation; Pittseal 444.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-76-8.
    b. Foster Products Corporation, H. B. Fuller Company; 95-44.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.8 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Vimasco Corporation; Elastafab 894.

B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.

1. Products: Subject to compliance with requirements, :

a. Childers Products, Division of ITW; Chil-Glas No. 5.

C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.10 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by COTR.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; Metal Jacketing Systems.
b. PABCO Metals Corporation; Surefit.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper or 2.5-mil- thick Polysurlyn.
d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper or 2.5-mil- thick Polysurlyn.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.

7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Polyguard; Alumaguard 60.

F. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

G. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
b. Compac Corp.; 110 and 111.
c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
b. Compac Corp.; 130.
c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
d. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    b. Compac Corp.; 120.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
    d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches.
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.

2. Width: 3 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.13 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products; Bands.
    b. PABCO Metals Corporation; Bands.

c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing or closed seal.

3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head.
4) Nelson Stud Welding; CHP.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

4. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) GEMCO.
      2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, galvanized steel.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. C & F Wire.
   b. Childers Products.
   c. PABCO Metals Corporation.

2.14 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. Color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and prepare surfaces to be insulated. Remove materials that will adversely affect insulation application.

B. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

Q. PVC Jackets

1. Provide a color coded jacket system for chilled water and domestic water systems. Colors shall be approved by FAA resident engineer.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum, at least 0.050 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Engine Generator Breechings and Ducts:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of

lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.8 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.9 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.10 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.11 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory pre-sized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install pre-sized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.

4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.12 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 07 84 13 "Penetration Firestopping."

3.13 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

    a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by COTR. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.14 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by COTR, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by COTR, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, randomly selected by COTR, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.15 ENGINE GENERATOR EXHAUST INSULATION SCHEDULE

A. Round, exposed breeching and connector insulation shall be the following:

1. Calcium Silicate: 4 inches thick.

B. Round, concealed breeching and connector insulation shall be the following:

1. Calcium Silicate: 4 inches thick.

3.16 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in nonconditioned space.
4. Indoor, exposed return located in nonconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.17 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Indoor, concealed supply and outdoor air:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Applies to rectangular duct only.
3. Minimum Thermal property: R-4.

B. Indoor, exposed supply and outdoor air:

1. Insulation integral to double-wall duct.
2. Minimum Thermal property: R-4.

C. Indoor, concealed return located in nonconditioned space:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Applies to rectangular duct only.
3. Minimum Thermal property: R-4.

D. Indoor, exposed return located in nonconditioned space:

1. Insulation integral to double-wall duct.
2. Minimum Thermal property: R-4.

E. Indoor, concealed exhaust between isolation damper and penetration of building exterior:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Applies to rectangular duct only.

F. Indoor, exposed exhaust between isolation damper and penetration of building exterior:

1. Insulation integral to double-wall duct.
2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. Applies to rectangular duct only.

3.18 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:

1. Cellular Glass: 2 inches thick.
2. Flexible Elastomeric: 1 inch thick.

D. Heat-exchanger (water-to-water for cooling service) insulation shall be one of the following:

1. Cellular Glass: 2 inches thick.
2. Flexible Elastomeric: 1 inch thick.

E. Chilled-water pump insulation shall be the following:

1. Cellular Glass: 3 inches thick.

F. Chilled-water buffer and expansion tank insulation shall be one of the following:

1. Cellular Glass: 2 inch thick.
2. Flexible Elastomeric: 1 inch thick.

G. Chilled-water air-separator insulation shall be one of the following:

1. Cellular Glass: 2 inches thick.
2. Flexible Elastomeric: 1 inch thick.

H. Piping system filter-housing insulation shall be the following:

1. Cellular Glass: 2 inches thick.

3.19 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.20 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. Insulation shall be the following:

   a. Cellular Glass: 1-1/2 inches thick.
   b. Flexible Elastomeric: 1 inch thick for use on instrumentation, thermal wells, sensors and valve stems only.

B. Chilled Water , above 40 Deg F:

1. Insulation shall be the following:

   a. Cellular Glass: 1-1/2 inches thick.
   b. Flexible Elastomeric: 1 inch thick for use on instrumentation, thermal wells, sensors and valve stems only.

C. Hot Service Drains:

1. Insulation shall be the following:

   a. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

3.21 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled-Water Supply and Return:

1. Insulation shall be the following:

   a. Cellular Glass: 2 inches thick.

3.22 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None.

E. Equipment, Concealed:

1. None.

F. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Corrugated: 0.032 inch thick.

G. Piping, Concealed and Exposed:

1. PVC, Color-Coded by System: 20 mils thick.

3.23 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

1. Aluminum, Corrugated: 0.032 inch thick.

END OF SECTION 23 07 00

SECTION 23 08 20 - HVAC COMMISSIONING - GENERAL

PART 1 GENERAL

1.1 DESCRIPTION

A. The purpose of the Commissioning process is to provide the FAA with a higher level of assurance that the systems have been installed in the prescribed manner and will operate within the performance guidelines. The Commissioning Agency shall provide the FAA an unbiased, objective view of the systems' installation, operation, and performance. This process is not to take away or reduce the responsibility of the system designers or installing Contractor(s) to provide a finished product. It is not intended to be an additional or redundant testing/inspection function, but shall enhance the quality of system start-up and aid in the orderly transfer of systems to beneficial use by the FAA.

B. The function and responsibility of the Commissioning Agency shall include:

1. Responsibility: The primary point of responsibility to inform the FAA on the integration and performance of systems within the facility.

2. Information: Disseminate information and assist the Contractor to complete the certification process. This shall include system completeness, performance, and adequacy to meet the intended performance standards of each system. Services include construction observation, testing, and providing performance information to the responsible parties, i.e., contractors, vendors, and FAA.

3. Leadership/Training: Initiate and lead the involvement of the facility operations people in the Commissioning process. Setting standards, involving the technicians in the certification process and educating operations personnel on each system.

4. Quality Assurance: Assist the responsible parties to obtain quality equipment, installation, and performance of systems.

5. Arbitration of Disputes: The Commissioning Agency is to remain an independent party present on the project with specific knowledge of the project. Should disputes arise, the Commissioning Agency shall complete research to determine the scope and extent of the problem, educate the involved parties on the nature and extent of the problem. The Contracting Officer will preside over resolution of the dispute. This would include all technical and financial aspects of the dispute, including determination of who the responsible parties are to implement corrective actions.

6. Observation of Tests: Observe and/or perform all required testing to certify adequate system performance.

7. Documentation of Tests: Document the results of the performance testing directly and/or ensure that all testing is documented by the appropriate technicians. The Commissioning

Agency shall provide standard forms to be used by all parties for consistency of approach and type of information to be recorded.

8. Acceptance: Determine the date of acceptance for each component and system for start of the warranty period.

C. The Commissioning Agency is referred to as an independent contractor in this Division and shall be a service provided by the Contractor for the FAA by a company approved by the FAA.

1.2 COORDINATION

A. The Commissioning Agency shall coordinate directly with each contractor on the project specific to their responsibilities and contractual obligations. If the contractor is a sub-contractor to another contractor, written information shall be provided to all responsible parties relative to the nature and extent of the communication. If contractual obligations are in question, then the prime contractor shall be contacted by the Commissioning Agency to determine the extent and scope of responsibilities and change orders, if appropriate.

B. The Commissioning Agency is primarily responsible to the FAA, and as such, shall regularly apprise the RE of progress, pending problems or disputes, and shall provide regular status reports on progress with each system. Any potential change in the contractual and/or financial obligations of the FAA shall be identified as soon as they are known. Any such change shall be quantified as soon as possible.

C. Refer to other HVAC Commissioning Sections for additional details as to the expectations of the Commissioning Agency with respect to specific systems.

1.3 SCHEDULE

A. Commissioning of systems shall proceed per the criteria established in the other Division 18 sections, with activities to be performed on a timely basis. The Commissioning Agency must be available to respond promptly to avoid Contractor delay.

B. Commissioning of systems may proceed prior to final completion of systems to expedite progress. However, the Commissioning Agency shall not perform testing and check out services that are the primary responsibility of the contractor/vendor in advance of their testing and checkout.

1. Problems observed shall be addressed immediately, in terms of notification to responsible parties, and actions to correct deficiencies.

2. Schedules and scheduling is the responsibility of the Contractor. Commissioning requirements must be coordinated with the approval of the Contractor. The Commissioning Agency must provide commissioning scheduling information to the Contractor for their review and planning activities.

1.4 RELATED WORK

A. Commissioning is the primary responsibility of the Commissioning Agency, with secondary and support responsibility by the Contractor. The commissioning process does not relieve the subcontractors from participation in the process or diminish their role and obligations to complete all portions of work in a satisfactory and fully operational manner.

B. Participation by the Commissioning Agency shall include the following work as specified in this division:

1. Observation of the start-up and initial testing by the Contractor.

2. Provide qualified personnel for participation in commissioning tests, including seasonal testing required after the initial commissioning.

3. Provide engineering and technical expertise to oversee and direct the correction of deficiencies found during the commissioning process.

4. Review operation and maintenance information and as-built drawings provided by the various Contractors and vendors for verification, organization, and distribution.

5. The contractors and vendors shall provide assistance to the commissioning team to develop and edit operation descriptions by system.

6. Assist with training for the systems specified in Division 15 in coordination with the Contractor.

PART 2 - PRODUCTS

2.1 TEST EQUIPMEMT

A. All industry standard test equipment required for performing the tests specified herein shall be provided by the Commissioning Agency, with proprietary vendor specific test equipment to be provided by the manufacturer.

B. The Commissioning Agency's instrumentation shall meet the following standards:

1. Be of sufficient quality and accuracy to test and/or measure system performance within the tolerances required to determine adequate performance.

2. Be calibrated on the manufacturer's recommended intervals with calibration tags permanently affixed to the instrument being used.

3. Be maintained in good repair and operating condition throughout the duration of use on this project.

4. Be recalibrated/repaired if dropped and/or damaged in any way during use on this project.

PART 3 - EXECUTION

3.1 BASIS OF DESIGN DOCUMENTATION

A. Provide narratives to include design criteria and design intent for each system as itemized in Section 3.2 below, with the addition of all supply and exhaust air-handling systems.

3.2 ONE-LINE DIAGRAMS

A. One-line diagrams shall be required to support narrative system descriptions and the overall commissioning process. Depending on the system in question, the following procedures for developing the one-line diagram are to be employed:

B. Update the existing riser diagrams that have been provided in the Contract Documents. Some revisions may be required to match desired format for Commissioning Documents. This method shall be employed for the following systems:

1. Hot Water Heating
2. Air Handling Equipment
3. Chilled Water Cooling

3.3 OPERATING DESCRIPTIONS BY SYSTEM

A. A narrative shall be prepared describing the operation of each system. The Contractor shall develop from the contract specifications the draft document, the vendors shall have input into editing these narratives, and subsequently the Contractor shall then complete another interim edit. Subsequently, the Contractor shall oversee training, re-editing, and publishing of the final operations narratives.

3.4 MAINTENANCE PROCEDURES

A. A narrative is to be prepared describing the Maintenance Procedures required for each system. The Contractor shall develop from the contract specifications the draft document, the vendors and manufacturer’s representative shall have input into editing these narratives, and subsequently the Contractor shall then complete another interim edit. Subsequently, the Contractor shall oversee training, re-editing, and publishing of the final maintenance procedures.

3.5 TECHNICAL REFERENCE MANUALS

A. Compile and organize vendor-provided equipment technical reference materials. This function includes gathering, inventory, editing, and review.

B. The equipment manufacturer must provide standard technical literature relative to the operation and maintenance of the provided equipment. The literature shall be specifically orientated to the provided equipment indicating all operation and maintenance procedures, parts lists, assembly/disassembly diagrams, and related information. Wiring diagrams must be complete and specific to the equipment provided.

C. The Commissioning Agency must incorporate the standard technical literature into a systems specific format for this facility as designed, and as actually installed. The resulting operation and maintenance information shall be system specific, concise, and to the point, and above all tailored specifically to this facility.

3.6 OBSERVE CONSTRUCTION

A. This is an additional and separate activity from that provided by the RE. This is additional construction observation required as part of the commissioning process to be provided by the Commissioning Agency.

3.7 TEST AND BALANCE

A. Air and water balance and equipment capacity verification shall be completed by an independent Test and Balance firm under contract to the Contractor in accordance with Specification Section 23 05 93.

3.8 FUNCTIONAL PERFORMANCE TEST PROCEDURES

A. Personnel experienced in the technical aspects of each system to be commissioned shall develop and document the commissioning procedures to be used. Include a performance checklist and performance test data sheets for each system based upon actual system configuration. These procedures shall be reviewed and edited by the appropriate Commissioning Agency engineers for technical depth, clarity of documentation, and completeness. Special emphasis shall be placed on testing procedures that shall conclusively determine actual system performance and compliance with the design intent.

B. The majority of mechanical equipment requires integral safety devices to stop and/or prevent equipment operation unless minimum safety standards or conditions are met. This could include adequate oil pressure, proof-of-flow, non-freezing conditions, maximum head pressure etc. The Commissioning Agency must observe the actual performance of safety shutoffs in a real or closely-simulated condition of failure.

C. Systems may include safety devices and components that control a variety of equipment operating as a system. Interlocks may be hardwired or installed via software. These interlocks shall also be verified by the Commissioning Agency.

D. The Commissioning Agency must determine the acceptance procedures for each system within Divisions 23 disciplines. The acceptance procedures must incorporate the commissioning standards and successful testing results as referred to throughout Divisions 23 specifications.

E. The appropriate contractor and vendor(s) must be informed before commissioning is started what the tests and expected results will be. Whereas some test results and interpretations may not become evident until the actual test are performed, all parties should have a reasonable understanding of the requirements. The commissioning plan must address those requirements and be distributed to all parties involved with that particular system.

F. Acceptance procedures must confirm the performance of systems to the extent of the design intent. When a system is accepted, the FAA must be assured that the system is complete, works as intended, is correctly documented, and is trained in the operation and maintenance of the system.

3.9 REVIEW SOFTWARE DOCUMENTATION

A. Review vendor/contractor provided detailed software documentation. This includes obtaining vendor documentation, a review of their programming approach, and a review of the specific software routines as applied to this project. Discrepancies in protocol or programming approaches shall be resolved to provide the FAA with the most appropriate, simple and straightforward approach to software routines.

3.10 FUNCTIONAL PERFORMANCE TESTING-OBSERVATION

A. The functional performance test shall be done by the contractors and vendors. The appropriate engineers and technicians who have significant field expertise with the appropriate system shall witness, verify, and assist with the tests.

B. Tests shall be completed comprehensively and to the extent to enable the Commissioning Agency to assure the FAA that the systems do perform to the full intent of the design. Once a system has successfully passed the performance testing, as addressed by the Commissioning Agency, the Commissioning Agency shall become responsible to the FAA for adequate system performance with reasonable margin for normal system degradation and given normal operation and maintenance procedures.

3.11 TRAINING

A. Provide assistance in coordination with the Contractor for operations training for the FAA’s staff for each system using videotape documentation. Training shall be in a classroom setting with the appropriate schematics, handouts and visual/audio training aids.

B. The Commissioning Agency shall host each training session with program overview and curriculum guidance.

C. The equipment vendors shall provide training on the specifics of each system and philosophy, troubleshooting, and repair techniques.

D. The installation contractors shall provide training on peculiarities specific to this project and job specific experience.

3.12 RECORD DRAWINGS

A. Provide assistance to the Contractor in production of the red-line As-Built contract documents to incorporate design changes and contractor records of construction.

3.13 COMMISSIONING PLAN AND SCHEDULE

A. The Commissioning Agency shall develop an integrated schedule for the Commissioning Process with the construction schedule. Included shall be the required work by all team members, contractors, and FAA. (Overlay with construction schedule, functional performance testing, and input to contractors).

3.14 EXCLUSIONS

A. Responsibility for construction means and methods. The Commissioning Agency is not responsible for construction means, methods, job safety, or any management function on the job site.

B. Hands-on work by the Commissioning Agency. The Contractor shall provide all technician services requiring tools or the use of tools to test, adjust or otherwise bring equipment into fully operational state. The Commissioning Agency shall observe technicians as they complete testing, and may make minor adjustments, but shall not perform construction or technician services other than normal test and balance functions.

END OF SECTION 23 08 20

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SECTION 23 09 23 - CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

1.2 RELATED SECTIONS

A. This section includes the Building Management System (BMS) control equipment for HVAC (Heating, Ventilation and Air Conditioning) systems and components, including but not limited to Servers, Network Controllers, Field Bus Controllers, Sensors, End Devices and communication networks required for a complete and functional control system.

B. Depending on the scope of the project, the complete specification may have numerous sections that interface to this section, including several from Division 23

1.3 DEFINITION OF TERMS AND ABBREVIATIONS

A. Architecture for BMS Systems:

1. Bus Topology: A term used to describe the sequential connection of devices on a LON segment. The communication cable runs from device to device with no tees or stubs from the main communication cable to a device. Also referred to as daisy chain wiring.
2. Channel: A LON network consisting of one segment with no LON routers or repeaters or multiple segments connected by repeaters.
3. Field Bus: Field bus is a generic term referring to control networks that connect multiple control devices that share a common protocol and common electrical communication characteristics. A field bus does not use TCP/IP for data transfer. Two very common examples are the FT-10A LON field bus and the RS485 Shielded Twisted Pair field bus.
4. Free Topology: A data wiring topology supported by LON that allows for loops, tees, y-connections, etc. When this topology is used, only one terminator of a specific design is required and allowable cable lengths are significantly reduced.
5. LAN (Local Area Network): A LAN is an organizations IP network serving a local area where data transfer between multiple components on the LAN does not involve transport over public physical IP networks.
6. LON to LON Router: A physical device used to connect two channels. These devices filter message traffic based on subnet numbers.
7. Repeater: A physical device used to connect two segments. A repeater does not filter any message traffic. A repeater does isolate physical problems such as short circuits to a single segment and is typically required to allow the use of additional devices or additional cable length.
8. Terminator: An electronic component that consists of a resistive and capacitive circuit specifically designed to enhance the quality of communications on a segment. With bus

topology, a termination device is required at both ends of the segment. With free topology, only one termination device is required at any point on the network.

9. WAN (Wide Area Network): This is also referred to as the Enterprise Network. The WAN is an organizations IP network that is made up of a collection of Local Area Networks (LAN) belonging to the organization. Dataflow between LANs may utilize public physical networks but the dataflow is private and secure.

a. BMS Control Components: The detailed technical specifications for the following components are included in Section 2.

1) ASC (Application Specific Controller): A subset of application specific devices (ASD). An ASC has physical inputs, physical outputs and control logic. It does not fit in the category of sensor or end device. Example: Xenta 102AX VAV controller.
2) ASD (Application Specific Device): A sensor, controller, or end device that is pre-programmed by the vendor. It may have physical inputs and physical outputs. The control logic, while not programmable, may be configurable through the use of configuration parameters. The application may require input network variables and may send output network variables. Example: Xenta 422A IO Device when commissioned in a stand-alone mode
3) DCU (Distributed Control Unit): A proprietary name for a programmable process controller in the SmartStruxure product line.
4) ES (Enterprise Server): A computer hosted server that coagulates the databases from multiple Network Server Controllers. Example: SmartStruxure Enterprise Server
5) NSC (Network Server Controller): An IP level controller and router. It connects to the IP level of the system architecture to multiple field busses that use LonTalk, BACNet MSTP and ModBus RTU. It may also support a field bus that uses a proprietary protocol such as the Schneider Electric SmartStruxure protocol. Example: SmartStruxure Automation Server
6) PEM (Packaged Equipment Module): An application specific controller that is native to a HVAC equipment item. Within the HVAC industry these controllers will typically fall into one of three categories; LON, BACnet or Modbus. Example: A VFD with an integral LON communications card
7) PCU (Process Control Unit): A proprietary name for a programmable process controller in the SmartStruxure product line.
8) PPC (Programmable Process Controller): A controller with provisions for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air-handling unit, chiller or boiler. The control logic for the sequence of control is created using an application programming editor that is compatible with the controller. A programmable process controller may or may not have data management features such as time schedules, trend data storage and alarm message generation capabilities. These features may be provided by another device using network communication to and from the PPC. Example: Xenta 302 Programmable Controller
9) SLC (Supervisory Logic Controller): A device that does not use physical inputs or physical outputs. It collects data over the network from other devices, applies logic to the data, generates instructions for use by other

devices and sends the instructions to the appropriate device. Example: Xenta 401B Programmable Controller

10) Add other device descriptions as necessary.

b. BMS Tools and Software

1) Application Programming Tool: A software tool used to create control logic for use in a Network Server Controller, a Programmable Process Controller or a Supervisory Logic Controller. Application Programming Tools are vendor unique and may require a separate operating license.
2) Graphical Programming: A concept where mathematical and logical algorithms are represented by graphical objects. Control logic is laid out by placing objects on a palate and connecting the output of one object to the input of the next object.
3) Graphics Editor: A software tool use to create dynamic graphical displays. A Graphics Editor is vendor unique and may require a separate operating license.
4) Line Programming: Application programming that uses line by line code that is similar to FORTRAN, Basic or C+ programming. Master programs and subroutines are created to meet a sequence of control.
5) LON Network Configuration: The process of addressing devices in an ANSI/EIA 709.1 environment. Also the process used to implement LON bindings between devices in the same ANSI/EIA 709.1 environment.
6) Web Server: Software that is installed on an Enterprise Server and/or Network Server Controllers to enable access by an operator using an industry standard web browser such as Internet Explorer or Google Chrome.
7) Workstation Presentation Software: Vendor unique software that allows an operator to access an Enterprise Server and/or a Network Server Controller for operation or engineering purposes.

c. Communication

1) Bandwidth Utilization: The average utilization of the LON FT-10A network in percent measured over a specified period of time as measured by a protocol analyzer.
2) Data Propagation Parameters: To ensure appropriate data transfer from device to device without excessive bandwidth utilization, sending devices will utilize a combination of communication parameters.

   a) Maximum Send Time: An adjustable parameter that defines the maximum time period between multiple transmissions of the same data element. This parameter ensures periodic data transfer even if the data has not changed its state or value.
   b) Minimum Send Time: An adjustable parameter that defines a mandatory time period during which the device must wait prior to sending the same data element a second time. This parameter ensures that data is not sent too often resulting in excessive bandwidth utilization.
   c) Send on Delta: An adjustable parameter that defines a requirement to send an element of data as a result of the data changing by an amount

that exceeds this parameter's value. For binary data, a change of state is the default. Minimum send time and maximum send time parameters have priority over send on delta. Between the minimum send time and the maximum send time, the send on delta will govern the sending of data.

d) The maximum send time parameter is mandatory.

e) Either the minimum send time parameter or the send on delta parameter must be used. Both may be used. When minimum send time is not used, the system performs as if the minimum send time is zero seconds.

3) LON Binding: The concept of associating an output network variable on a LON device to an input network variable on a second LON device.

a) One-One: A single network variable is bound to a single input network variable.

b) One-Many: A single network variable is bound to input network variables on multiple devices.

4) LON Binding Services: The description of how data is sent from device to device using LON bindings.

a) Unacknowledged: The data is transmitted once. No acknowledgement is expected.

b) Unacknowledged/Repeated: The data is transmitted multiple times with a delay between each send. No acknowledgement is expected. The number of sends and the time between sends is typically adjustable.

c) Acknowledged: The data is transmitted and the sending device waits for an acknowledgement message from the receiving device. If an acknowledgement message is not received within a specified period of time, the process will be repeated. This binding service is never used on a one-many binding.

d. Control Applications

1) Algorithm Execution Sample Rate: How often a mathematical algorithm in a controller generates a new or updated value.

2) Analog Calibration Offsets: For all analog input measured variables, there is a requirement to adjust the value measured by the hardware based analog input point to match the value reported by a certified test instrument.

3) Dead Zone: With respect the performance of a PID algorithm, the dead zone is the range of an input variable to the PID above and below the set point for which the output of the PID algorithm shall not be changed. Once the input variable gets within the dead zone, it is fruitless to attempt changes to get the input variable any closer to the set point. Assigning a dead zone to a PID loop improves stability and reduces wear and tear on the actuator.

4) Dynamic Data: Data that is calculated within control logic and is viewable by the system operator.

5) Floating Control: Floating control is a control loop algorithm used for fast responding airside and waterside pressure and flow control loops. Key parameters are the set point, the neutral zone, the bump rate and the algorithm sample rate.
6) Forced by Operator: Sometimes referred to as Manual Control. When a software object is "Forced by Operator", the value or state of the object is assigned by the operator and a value or state that flows to the object from another object or by physical measurement is blocked.
7) PID: Proportional-Integral-Derivative control. Key parameters are the set point, the gain, the interval time constant, the derivative time constant and the dead zone. Integral gain is defined as the gain divided by the interval time constant. Derivative gain is defined as the gain multiplied by the derivative time constant.
8) Points: Software objects associated with physical inputs and physical outputs (sensors and end devices). Input points receive their value or state from a sensor. Output points receive their value or state from the control logic.
9) User Adjustable Parameters: Parameters within the control logic that have a fixed but adjustable value or state. The value or state is set by the system operator. The parameters are initially programmed with a default value.

e. Equipment

1) AHU (Air Handling Unit)
2) FCU (Fan Coil Unit)
3) TU (Terminal Unit)
4) VAV (Variable Air Volume)
5) VFD (Variable Frequency Drive)
6) EDH (Electric Duct Heater)

f. Facilities

1) FAA facilities are typically operational 24/7. As such, some work in existing facilities may require off normal work hours.

g. Qualified System

1) The DDC Control System shall be the SmartStruxure System as manufactured by Schneider Electric.

a) Field Bus Controllers for new work shall be from the Xenta LON family of field bus controllers.
b) The b3 BACnet, MNL Lon and MNB BACnet field bus controllers under SmartStruxure shall not be used for new work.

2) HVAC components with integral PEMs that utilize one of the following protocols may be part of the proposed solution.

a) LONtalk
b) BACnet MSTP

c) BACnet IP
d) ModBus RTU
e) ModBus TCP

h. Pre-Approved Bidders: Only pre-approved installers are eligible to perform work on Terminal FAA projects. The following companies are known to be pre-approved installers for this project.

1) Future Controls, Inc.,
5719 Zip Drive, Suite 1,
Fort Meyers, Florida 33905,
800-330-1303, Attn: Thomas Hansen, Jr.

i. Qualifications:

1) All work described in this document shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the approved manufacturer's local field office.
2) The approved manufacturer's local field office shall have a minimum of 3 years of installation experience with the manufacturer and shall provide documentation in the bid and submittal package to verify this requirement has been met.
3) Supervision, hardware and software engineering, calibration, tuning and functional testing of the system shall be by the employees of the approved manufacturer's local field office and shall not be subcontracted.
4) The BMS contractor shall have factory certified technicians and engineers, spare parts inventory and all necessary test and diagnostic equipment for the installed system.
5) The BMS contractor shall have 24 hour per, 7 days per week emergency service available.

1.4 SCOPE OF WORK

A. The contractor shall furnish, install and commission a complete building automation system including all necessary hardware, networks, wiring, custom applications and operating software required to perform the control sequences of operation as called for in this specification and on the contract drawings. Systems to be controlled shall include but not be limited to:

1. Air Handling Units (AHU)
2. Fan Coil Units (FCU)
3. Variable Air Volume Terminal Units without fans and reheat
4. Monitoring and Control points for equipment indicated.

B. The complete building automation system shall, as a minimum, include the following items. The technical specifications for each of these items are included in Part 2 of this document.

1. All necessary Operator Work Stations, Enterprise Servers, and Network Server Controllers at the WAN/LAN level of the system architecture.
2. All necessary Field Bus Controllers at the field bus level of the system architecture.

3. All necessary WAN/LAN controllers that use the BACnet IP or ModBus TCP protocols.
4. All necessary sensors, transducers, relays, valves, valve operators, dampers, damper operators, control panels and other accessory equipment.
5. All necessary network wiring and electrical interlocking wiring to meet the intent of the specification and provide a complete and operable system.

   a. All wires shall be labeled at both ends to facility wire tracing

6. All necessary networking components such as Lon to Lon Routers, Lon Repeaters and network termination devices.
7. All control components shall be labeled so that the component can be easily associated with the design drawings/submittals.
8. All network wiring and hardware required to integrate existing Schneider Electric SmartStruxure systems as required by the contract drawings.
9. Power wiring to BMS panels, BMS components and smoke control dampers except as otherwise specified. Power wiring shall be provided under Division 26 (Electrical).
10. Except as otherwise specified, provide operators for equipment such as dampers and valves on equipment provided by other contractors when these items are not provided as part of the equipment provided by the other contractors.
11. All custom applications in the Enterprise Server, Network Server Controllers, Programmable Process Controllers and Supervisory Logic Controllers.
12. Fully configured applications in all application specific devices.
13. All modifications to Schneider Electric SmartStruxure applications required to enable the combined systems to meet the complete sequences of operation.
14. All trend logs required by this specification and the contract drawings.
15. All alarms with alarm routing required by this specification and the contract drawings.
16. All operator graphic pages required by this specification and the contract drawings.

C. Work Associated With Other Contractors

1. The BMS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extend of others' work
2. The BMS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.
3. The BMS Contractor shall provide field supervision to the designated contractor for the installation of the following.

   a. Automatic control dampers
   b. Blank-off plates for dampers that are smaller than duct size
   c. Sheet metal baffles plates to eliminate stratification

D. Calibration: Calibration of all analog sensors under normal operating conditions. Off season calibration may be required for this task. Example: Calibrating a chilled water temperature sensor must be accomplished when the chilled water system is in operation. Submission requirement for calibration plans and reports are described in the Submittal section of this document.

E. Loop Tuning: Tuning of all P, PI and PID control loops under normal operating conditions. Off season tuning may be required for this task. Example: A mixed air damper control loop is not in operation when the outside air temperature is 90 deg F. A mixed air damper control loop is typically in modulation mode when the outside air temperature is less than 60 deg F. Submission requirement for loop tuning plans and reports are described in the Submittal section of this document.

F. System Start-Up and Start-Up Testing.

1. The BMS contractor shall set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, working in a support role to the Mechanical Contractor. The Owner’s representatives shall have the opportunity to be present.

2. Start-Up Testing is the process of verifying the system is physically complete and properly installed in accordance with the approved installation submittals.

   a. It does not include calibration of analog sensors as the systems may not be in a state to support calibration efforts.
   b. It does not include loop tuning as the systems may not be in a state to support loop tuning.
   c. It does not include functional testing.

3. Start-Up Testing may be accomplished on a per component basis.

   a. Each Network Server controller with its embedded physical IO may be the subject of one Start-Up Test.
   b. Each Field Bus Controller with its connected physical IO may be the subject of one Start-Up Test.
   c. Each network can be tested as part of a Start-Up Test.

4. Start-Up Testing may be accomplished on a per control panel basis where a control panel contains multiple components.

5. Start-Up Testing tasks shall include as a minimum the following.

   a. Verification of component inventory compared to the submittals
   b. Measurement of voltage sources; line voltage, low voltage AC and DC
   c. Verification that the power consumption of all devices connected to a single power source does not exceed the power capacity of the power source
   d. Verification that devices that required half wave power are not powered from the same source as devices that require full wave power
   e. For each controller, verification of correct controller:

      1) Power wiring (voltage, VA, full wave versus half wave)
      2) Grounding
      3) Communication wiring

   f. Verification that each IO device is landed per the submittals and:

1) Analog sensors are properly scaled and a value is reported
2) Binary sensors have the correct normal position and the state is correctly reported
3) Analog outputs have the correct normal position and move full stroke when so commanded
4) Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.

g. For each communication network, verification of:

1) Bus topology
2) Polarity is consistently maintained device to device on RS485 networks
3) Shielded wire is used where required
4) Wire characteristics match the type required (LON, RS485)
5) The AWG of the cable does not change within a single segment and it is per the submittals
6) Single point grounding of shields and continuity of the shield over each segment of the network (when shielded wire is used)
7) The installation of the correct terminal devices at the both ends of each segment (FT-10A Networks)
8) Terminal resisters are installed at the end of each segment for RS485 networks
9) Biasing power sources and resistors are properly installed per the design.
10) The installed unit load of RS485 devices does not exceed the calculated maximum.

h. For all wiring verify that:

1) All wires are labeled such that both ends of each wire can be easily identified
2) Connection integrity and quality is good (no loose strands and no loose connections)
3) All cabling shall be installed “uncut” in a single continuous run from starting point to ending point without splices when practical. (Note: at a minimum, conductors within the same room, same system, and common origin shall be considered practical).

6. Submission requirement for start-up testing plans and reports are described in the Submittal section of this document.

G. Functional Testing

1. When the system is fully installed and operational, the BMS contractor shall execute functional tests of the system in the presence of representatives of the owner.
2. The functional tests shall be written by the BMS contractor and shall be designed to verify all aspects of the sequence of operation. Off season functional testing may be required for some tasks.
3. Submission requirement for functional testing plans and reports are described in the Submittal section of this document.
4. Support for HVAC and Balancing Contractors: Provide software tools, services and manpower as necessary so that the HVAC and Balancing Contractors are equipped to

accomplish their functional testing and balancing tasks. The HVAC and Balancing Contractors will not be familiar with the BMS operator interface. The BMS Contractor may provide tools and training for these contractors to make them self-sufficient or provide a trained operator to support their efforts.

H. Support for Commissioning Agent: If an independent Commissioning agent effort is part of this project, the BMS Contractor shall provide software tools, services and manpower as follows so that the agent is equipped to perform commissioning tasks.

1. Submit a Commissioning Agent Support Plan as define in the Submittals Section of this document.
2. HVAC systems primarily consist of:

   a. Energy Source Systems such as chillers, boilers, etc.
   b. Energy Delivery Systems such as air handling units or piping systems.
   c. Terminal Units such as Fan Coil Units, VAV Terminals, Unit Heaters, Pumps, etc.
   d. Third Party End Devices such as VFDs

3. The BMS Contractor shall provide an engineering technician that was significantly involved with the installation of the BMS System and is fully trained to operate the installed system. This technician shall:

   a. Using Contract Documents and Facility Architectural Plans, brief the Commission Agent on the location of BMS components within the facility.
   b. Furnish custom tools and cables that are unique to the BMS and not generally available in the commercial market.
   c. Execute operator tasks as instructed by the commissioning agent.
   d. Make minor engineering changes to the system such as adding trend logs, changing parameter values, overriding automatic control, etc.
   e. Extract performance data from the BMS system for the Commissioning Agent.

4. The BMS Contractor personnel shall not be tasked to assist in the physical tasks associated with verifying system performance such as accessing system components, taking measurements, observing the physical status of end devices, etc. The primary task for the supporting technician is to operate the BMS system.
5. The BMS Contractor shall provide support to the Commissioning Agent in accordance with the following manpower budget:

   a. 16 Man-hours for each energy source system
   b. 16 Man-hours for each energy delivery system
   c. 2 Man-hours for each terminal device.
   d. 4 Man-hours for each third party device
   e. 16 Man-hours for operator interaction tasks.
   f. Man-hours not expended for one system shall be available for other systems.
   g. The BMS Contractor is responsible for providing manpower to support CX, T&B and FAA turnover demonstrations.

6. When repeat testing is required by the Commissioning Agent as a result of the system not meeting the contract requirements during the first test, BMS Contractor support shall be provided at no additional cost to the Owner.

I. Operator Interaction Testing

1. When the system is fully installed and operational, the BMS contractor shall execute operator interaction tests of the system in the presence of representatives of the owner. This can be combined in the training specified in the next section.
2. These tests shall be written by the BMS contractor and shall be designed to verify all aspects of operator interaction with the system. Additional requirements will be found in the System Acceptance and Testing section of this document.
3. Test elements shall include but not be limited to:

    a. Graphics navigation
    b. Alarm viewing, acknowledging, inhibited and routing
    c. Viewing trend log lists and trend charts
    d. Time schedule editing
    e. Application/configuration parameter adjustment
    f. Viewing data in the system tree
    g. Manual control of all objects that are equipped for this function
    h. Viewing reports
    i. Viewing application programs in the ES, NSCs, PPCs and SLCs (Engineering Workstation Only)
    j. Using the Search Function

4. Unless otherwise noted, verify that the above tasks can be accomplished from the Engineering Workstation and Web-Based Operator Workstations.
5. Submission requirement for operator interaction testing plans and reports are described in the Submittal section of this document.

J. Training

1. On-site training shall be focused on the tasks that are described in the Operator Interaction Testing Plan.

    a. Training will be customized to reflect operation of the delivered system.
    b. The BMS contractor shall provide forty (40) hours of on-site training.
    c. Training shall be provided for up to 10 of the Owner’s personnel.
    d. As part of the training, each student shall have the opportunity to perform each of the tasks in the testing plan.

K. Submittals: The contractor is required to submit technical information to the owner hear after referred to as “Submittals” at three different phases of the project:

1. Pre-Construction
2. During Construction
3. Post-Construction.

L. The requirements for each submittal are described later in this document.

M. Quantity Review: The BMS contractor shall review the entire specification and all contract drawings to determine the systems to be controlled, the operation sequences and the quantities and types of dampers, valves, operators, sensors, transducers, end devices required for a complete operational control system and to be provided by the BMS contractor.

1.5 WORK BY OTHERS

A. The Electrical Contractor shall provide:

1. All power wiring to motors, heat trace and junction boxes for power to BMS panels
2. Wiring between the smoke detectors and the building fire alarm system
3. Auxiliary contact (pulse type) on electric meters for central monitoring of kWH and KW by the BMS
4. The scaling parameters for the auxiliary contact on the electric meters to enable engineering of the electrical monitoring by the BMS contractor.

1.6 CODES, LAWS AND GOVERNING BODIES

A. All work performed under this section of the specification will comply with all governing codes, laws and governing bodies.

B. If the drawings and/or specifications are in conflict with governing codes, the Contractor, with guidance from the Owner, shall submit a proposal with appropriate modifications to the project to meet code requirements. If this specification and/or drawings exceed governing code requirements, the specification and drawings will govern.

C. The Contractor shall obtain and pay for all necessary construction permits and licenses.

1.7 CODE COMPLIANCE

A. BMS components and ancillary equipment shall be UL-916 listed and labeled as such.

B. All equipment and piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flam/Smoke/Fuel contribution ratings of 25/50/0 respectively and all applicable building codes or requirements.

C. All wiring shall conform to the National Electric Code.

D. Computing devices and low power communication equipment shall comply with FCC rules, Part 15 regarding Class A radiation in commercial environments.

1.8 SYSTEM DESCRIPTION

A. Operator Interfaces: In accordance with the scope of work and contract drawings, the system shall provide a graphical web-based operator interface that allows the operator to view data from and send data or commands to any system under control by the BMS through the use of a standard browser. The system shall also provide a personal computer based engineering workstation to allow system operators to perform engineering tasks such as editing applications, editing or creating graphics and adding new devices to the system. This engineering workstation shall also function as an operator workstation without the use of a standard browser and as an administrator workstation to allow the system administrator to establish secure access to the system and define dataflow between users and the system on a per user and user group basis.

1. The BMS contractor shall provide two (2) administrator and engineering workstations as described in Part 2 of this document. One (1) desktop with a minimum of 24" flat screen monitor and one (1) laptop with a minimum of a 15" screen. These workstations shall physically connect to the WAN/LAN layer of the system architecture.

    a. From this workstation the system operator shall be able to connect to the Enterprise Server and see the entire BMS system or connect to an individual Network Server Controller and see the systems controlled by the Network Server Controller and the field bus controllers managed by the Network Server Controller.
    b. From this workstation, the operator shall be able to perform all engineering and administrative tasks to install, program, configure, commission and operate the presented BMS system.

B. Enterprise Server (ES): The BMS contractor shall provide an Enterprise Server that connects to the system at the WAN/LAN layer of the system architecture.

1. The ES shall provide visibility into the databases in all of the Network Server Controllers as well as its own database via an Engineering Workstation or Web-based Workstations.
2. The ES shall be able to send and receive data from any Network Server Controller for implementation of the system wide sequence of operation.
3. The ES shall be able to:

    a. Host applications as necessary to meet the system wide sequence of operation.
    b. Upload and store trend log data from all Network Server Controllers.
    c. Host system wide graphical data displays.
    d. Host master time schedules for mirroring in Network Server Controllers.
    e. Host master calendars for integration with time schedules.

4. The ES shall support the use of the following for communication at the WAN/LAN layer of the system architecture using web services:

    a. HTTP: Hyper Text Transfer Protocol
    b. SOAP: Simple Object Access Protocol
    c. XML: eXtensible Markup Language

5. The ES shall be able to send and receive data to/from WAN/LAN based ModBus devices using ModBus Transmission Control Protocol (ModBus TCP).
6. The ES shall support the tunneling of LON ANSI/EAI 709.1 data over the IP in accordance with the ANSI/EIA 852-B standard.
7. The ES shall support the use of BACnet over IP using UDP.

C. Network Server Controllers: The BMS contractor shall provide, install and commission one (1) or more Network Server Controllers as necessary to meet the control requirements defined in this document and the requirements of the manufacturer's architectural guidelines.

1. These controllers will communicate with the following devices via the WAN/LAN with the capability to communicate at 100 megabits per second.

    a. The Enterprise Server
    b. Other Network Server Controllers
    c. Operator Workstation
    d. Engineering Workstation
    e. Web-based operation workstations

2. These controllers shall communicate with their embedded input and output devices via a dedicated bus.
3. These controllers shall communicate with LON field bus controllers via a dedicated 76.8 kilobit per second FT-10A LON field bus network.
4. These controllers shall communicate with up to 3 distinct RS485 networks. Use of the RS485 networks shall be selected from the following:

    a. ModBus RTU devices via a dedicated RS485 shielded twisted pair field bus network.
    b. BACnet MSTP devices via a dedicated RS485 shielded twisted pair field bus network.
    c. SmartStruxure DCUs and PCUs via a dedicated RS485 shielded twisted pair field bus network.
    d. When using RS485 devices under a Network Server Controller, the loading of the Network Server Controller must conform to vendor recommendations on the simultaneous use of the multiple RS485 networks and number of devices per network. In most cases, one of the three options will dominate with very limited loading on the other two RS485 networks.

5. The Network Server Controllers shall support the use of:

    a. Modbus TCP
    b. BACnet over IP using UDP

6. The Network Server Controllers shall support the use of the following for communication at the WAN/LAN layer of the system architecture using web services:

    a. HTTP: Hyper Text Transfer Protocol
    b. SOAP: Simple Object Access Protocol
    c. XML: eXtensible Markup Language

7. Network Server Controllers shall NOT communicate with the Enterprise Server or any workstation using RS232 or ARCNET.

D. Field Bus Controllers: Field Bus Controllers consist of Application Specific Devices, Programmable Process Controllers, Supervisory Logic Controllers and Packaged Equipment Modules. With limited exceptions, all field bus controllers shall be compatible with the EIA Standard 709.1 LonTalk™ protocol and be installed on a FT-10A LON field bus connected to one of the Network Server Controllers without the use of gateways or protocol translators.

1. These controllers shall have embedded FT-10A Transceivers to allow for connection to a FT-10A LON Network at 76.8 kilobits per second.
2. These controllers shall be LonMark certified or LonMark compatible.
3. Exceptions.

   a. In some cases, packaged equipment modules are not available with support for the LonTalkTM protocol. In such cases, devices that utilize BACnet MSTP, BACnet IP, ModBus RTU or ModBus TCP shall be used.
   b. These exceptions must be clearly defined on the pre-construction submittals.

E. Networks: The networks that allow for connection of the components that make up the BMS system shall exist in two layers; the Ethernet/IP layer (WAN/LAN) and the field bus layer. The devices that transition from the WAN/LAN layer to the field bus layer are Network Server Controllers.

1. WAN/LAN

   a. Enterprise Ethernet (IEEE 802.3), WAN: This network shall utilize CSMA/CD, ARP and UDP operating at 10 or 100 Mbps.
   b. Local Area TCP/IP Network, LAN: This network shall be either a 10 or 100 Mbps Ethernet network supporting BACnet Over IP, Modbus TCP, Java, XML, HTTP, SOAP and COBRA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers, an Enterprise Server, and multiple workstations (engineering or web-based).

2. Field Bus Layer: Field Bus Networks shall be FT-10A LON or RS485 Twisted Shielded Pair.

   a. FT-10A LON networks using the EIA Standard 709.1 LonTalkTM protocol shall connect to a Network Server Controller and support devices with FT-10A transceivers.
   b. RS485 Shielded Twisted Pair networks to support devices with RS485 transceivers shall connect to a Network Server Controller.

F. Environmental Control Equipment

1. The BMS system shall use electronic sensors and electronic/electric actuation of valves, dampers and two position electric circuits on central station HVAC equipment, HVAC terminal equipment, variable frequency drives, low voltage lighting control, electrical circuit breakers and power monitoring.
2. The BMS is intended to seamlessly connect devices throughout the building regardless of system type.

G. WAN/LAN Reliability

1. A Network Server Controller and all field bus controllers that are subordinate to the NSC represent a defined subset of the overall BMS.

2. Each NSC system shall be designed for the maximum possible standalone operation when the NSC can no longer communicate with other NSC or ES systems on the WAN/LAN.
3. When a specific piece of measured data (Example: Outside Air Temperature) is critical to the performance of two NSC systems, each NSC system shall have its own electronic sensor (to measure the Outside Air Temperature).
4. When schedules and set points originate in the ES, each NSC system shall hold the last data received from the ES until communication with the ES is re-established or the NSC system shall revert to local applications until communication with the ES is re-established.

H. Software Tools: Latest Licensed software at time of commissioning. Tools shall be provided in their original electronic format and be installed and configured on the appropriate devices for each software tool.

1. Enterprise Server: Software tools to address and configure the Enterprise Server for complete ES functionality.
2. Network Server Controllers: Software tools to address the NSC and to load the latest firmware into the NSC.
3. Field Bus Controllers: Software tools to address the field bus controllers and to load the latest firmware into the field bus controllers.
4. Custom Application Engineering: Software tools to create custom applications for the ES, NSCs and programmable Field Bus Controllers.
5. Application Specific Device Configuration: Software tool to configure parameters in application specific devices
6. Graphics Editor: Software tool to create dynamic graphic displays (pages) in the ES and NSCs.
7. License Administration: Software tool to manage all licenses for full and complete operation of the BMS system.
8. Workstation: Software to enable operation of the Engineering and Administrative operator workstation.
9. Web-Workstation: Software for the ES and NSCs to enable operation of web-based operator workstations.
10. Any other software required for a complete system that can execute all of the tasks defined in this document. The intent of this specification is that the Owner's system operators shall not be restricted from performing any operator or engineering task due to the absence of software or licenses.
11. The capability for simultaneous execution of tasks from multiple points of entry into the system is described in Part 2 of this document.

I. Custom Tools and Cables

1. One set of all custom tools and cables that are acquired from the BMS manufacturer and used during installation, configuration and engineering of the system.

J. Graphics

1. The type, quantity and technical requirements for graphic pages are described in Part 2 of this document.

2. Graphic pages that relate to systems and components that are controlled by a Network Server Controller (or devices on a field bus managed by the Network Server Controller), shall be located in the Network Server Controller.
3. Graphic pages that relate to systems and components that are controlled by multiple Network Server Controllers shall be located in the Enterprise Server.

K. Trend Log Data

1. Trend log data for values in a field bus controller.

a. If trend log data is collected in a field bus controller, the trend log data must be periodically uploaded to larger capacity trend logs in the Network Server Controller.
b. If trend log data is not collected in a field bus controller, the data to be trended shall be mirrored in the Network Server Controller and the mirrored data shall be logged in the Network Server Controller. The mirroring process shall use send on delta, minimum send time and maximum send time parameters to avoid excessive bandwidth utilization on the field bus.

2. Data that originates in the Network Server Controller shall be trended in the Network Server Controller.
3. Trend log data in the Network Server Controller shall be periodically uploaded to long term data storage in the Enterprise Server when applicable/provided.
4. All trends shall be local to the Smart Struxure Software and shall be set to the following: 15 minute snapshot / 14 day storage.

1.9 SUBMITTALS

A. Shop Drawings and Product Data.

1. Shop drawings shall be 11 inch by 17 inch, landscape, bound on the left edge. Organize the packages by building.
2. All text based documents and product data sheets shall be 8 ½ inch by 11 inch format bound on the left edge. To the maximum extent possible Adobe Acrobat shall be used to produce the documents in an X.pdf format.
3. Software files shall be submitted on fully labeled CDs that shall include a table of contents file in “filename.pdf” format that provides a description of all of the files on the CD.

B. Submittals Prior To Construction.

1. Shop Drawings

a. System Architecture Design Diagram.

1) This is a riser diagram of the WAN/LAN layer, all NSCs and all connected field busses. It shall show all BMS components to be installed on the WAN/LAN and all of the field busses.
2) This diagram shall include the existing control systems that are to be integrated into the common enterprise level system.

3) The physical relationship of one component to another component shall reflect the proposed installation. Example: If AHU1 controller is the closest controller to NSC on the field bus, then this device shall be shown as the first device on the riser diagram just below the NSC. This requirement does not apply to the existing control system.

b. Layout Design Drawing for each control panel:

1) All control devices shall be identified by name.
2) All terminal strips and wire channels shall be shown.
3) All control transformers and 120 VAC receptacles shall be shown.
4) All IP connection points shall be shown.

c. Wiring Design Diagram for each control panel.

1) The control voltage wiring diagram shall clearly designate devices powered by each control transformer.
2) The LON wiring diagram shall clearly show the order in which the devices are connected to the LON and the location of end of segment termination devices.
3) If shielded communication wiring is used, the grounding location for the shield shall be shown.
4) The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.

d. Wiring Design Diagram for individual NSCs and Field Bus Controllers: The wiring diagram for each component shall identify all I/O, power and communication wiring, and the locations on the terminal blocks to which wires are landed. Example: Fan Status sensor is wired from terminals 5/6 on the controller to terminals 17 and 18 on the terminal strip.

e. Installation Design Detail for each I/O device.
1) Include a drawing of the wiring details for each sensor and/or end device.
2) For devices with multiple quantities a standard detail may be submitted.

f. A System Flow Design Diagram for each controlled system.

1) A two dimensional cross sectional diagram showing key components such as fans, coils, dampers, valves, pump, etc.
2) Identify the locations and names of all sensors and end devices that are associated with the control system. Label the panel name and terminal numbers where the connections are landed.
3) A legend shall be provided for all symbols used.

2. Data

a. BMS manufacturer’s architectural guidelines that define the systems architecture, the number of devices supported at each level of the architecture and any other software or hardware limitations for an efficient system.

b. BMS Hardware Technical Data.

1) A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
2) Manufacturer's description and technical data for each unique device to include performance curves, product specification sheets and installation instructions. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
3) An Instrumentation List for each system. The list shall be in a table format and Include name, type of device, manufacturer, model number and product data sheet number.

c. Sequence of Control: A sequence of control for each system being controlled.

1) A list of all physical inputs and outputs associated with each sequence.
2) Identify those points that shall be subject to manual control from an operator workstation.
3) A list of all alarms, a description of the alarm and a description of the alarm criteria.
4) A list of all variables for which historical trending will be applied, the sample rates and any criteria used to start and stop the historical trending.

3. Submit five (5) copies of submittal data and shop drawings to the Owner for review and approval prior to ordering or fabrication of the equipment.
4. The Owner will annotate required corrections and return to the BMS Contractor. The BMS Contractor will then re-submit with corrected data or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Owner and the submittals are fully approved.

C. Submittals During Construction

1. Training Manuals for on-site BMS Contractor conducted training.

a. Six weeks in advance of the training, submit the following:

1) List of training objectives.
2) Outline of the course with time allocations per topic.
3) Methodology to be followed to ensure each student has a complete hands-on training experience.
4) Methodology to be followed to ensure each student masters the training objectives.

b. Submit the following within 3 weeks of training completion:

1) List of attendees.
2) Performance scores on the assessment devices.

c. Training sessions shall accommodate up to ten (10) participants for a minimum of three (3) days.

d. Two (2) days of follow up training shall be included within six (6) months of completion.

2. Startup Testing Plan: Submit a start up testing plan for each unique system.

a. The purpose of a startup test is to demonstrate the "completeness" of the physical tasks associated with installation and the physical performance of the components. See the Scope of Work Section in this document for a task list.
b. For each task on the startup test checklist, the plan shall require the technician to enter his or her initials and the date the test was completed along with any recorded data such as voltages, offsets or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.
c. Submit at least four weeks prior to any scheduled start-up tests.

3. Startup Testing Report: Startup testing reports shall be submitted on a per system basis. They shall be the documented results of the executed startup testing plans.
4. Performance Verification Testing Plan: Submit a verification plan for each system. For each end device that is controlled, the plan shall define a series of step by step cause and effect tests to verify each aspect of the sequence of control.
5. Performance Verification Testing Report: Performance Verification Testing Reports shall be submitted on a per system basis. Performance Verification Testing reports shall be the documented results of the executed performance verification testing plans with initials and dates.
6. Operator Interaction Testing Plan: Submit a verification plan for the Engineering Workstation and the Web-based Workstation. List each operator task to be accomplished as part of the test. See the Scope of Work Section of this document for a list of tasks.
7. Operator Interaction Testing Report: Operator Interaction Testing reports shall be submitted for both types of workstations. The successful execution of each operator task with initials and date accomplished shall be documented in the report.
8. Calibration Report: A calibration report shall be submitted on a device by device basis listing the analog sensors that were calibrated and the final calibration offsets for each sensor.
9. Tuning Report: A tuning report shall be submitted on a device by device basis listing each P, PI or PID control loop that was tuned. The final sample rate, gain, integral time constant (if used) and derivative time constant (if used) shall be documented for each loop.

D. Submittals After Construction

1. As-built system architecture drawing.
2. As-Built layout drawing for each control panel.
3. As-built wiring diagram for each control panel.
4. As-built wiring diagram for individual components.
5. As-built system flow diagram for each controlled system.
6. As-built Instrumentation list for each controlled system.
7. As-built sequence of control.
8. Operation and Maintenance Manuals: Operations and Maintenance Manuals shall consist of two parts. Both parts shall be provided electronically on each workstation with links

to the information from the home page. Diagrams shall be on 11” by 17” files. If color has been used to differentiate information, the copies shall also be in color.

a. Part I: Information common to the entire system.

1) Product manuals for key software tasks.

a) Operating the system.
b) Administrating the system.
c) Application programming.
d) Engineering the network.
e) Graphics creation.
f) Reports creation.
g) All other engineering tasks.

2) List of recommended maintenance tasks associated with the Enterprise Server, Network Server Controllers and Engineering Workstation.

a) Define the task and the recommended frequency.
b) Reference the product manual that includes instructions on executing the task.

3) Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
4) Licenses, guarantees, and warranty documents for equipment and systems.
5) Submit three (3) copies of Part I information.

b. Part II: Information common to the systems in a single building.

1) As-built system architecture diagram for components within the building annotated with specific location information.
2) As-built drawing for each control panel.
3) As-built wiring design diagram for each control panel.
4) As-built wiring design diagram for all components.
5) As-built details for each I/O device.
6) As-built system flow diagram for each system.
7) As-built sequence of control for each system.
8) Product data sheet for each component.

c. Submit one copy for each building, plus two extra copies.

9. Software: Submit three (3) copies of all software, firmware, license files and library files listed in the OWNERSHIP section, of this document. For application specific devices, this shall include the xif file and nxe file.

E. Interface with the Owner’s IP Infrastructure
1. The system shall be on a stand-alone TCP/IP infrastructure and shall not be connected to the FAA backbone at any time.

1.10 OWNERSHIP

A. The BMS Contractor may use temporary licenses during the installation and commission of the system, but permanent licenses without expiration dates shall be installed on the system prior to completion. These license files shall be provided to the owner as part of the post construction submittals and they shall become the property of the owner.

B. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract.

1. The license agreement shall grant use of all software programs, firmware files, application library files, and graphical symbol library, files created by the contractor during engineering and installation and product documentation to the owner.
2. The Owner shall agree to the terms of the license agreement that protect the manufacturer's right to non-disclosure of Trade Secrets contained within all files provided to the owner.
3. The licensing agreement shall not preclude the use of the software and firmware by individuals under contract to the Owner for commissioning, servicing or altering the system in the future.
4. The Owner shall agree that use of the software and firmware by individuals under contract to the owner shall be restricted to use on the Owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

C. All software programs and tools, firmware files, application library files, graphics libraries and product documentation used on this project shall be provided to the Owner in a format that the Owner could install them on a computer or download them to a control component. This shall include but not be limited to:.

1. All software programs and tools as listed
2. Firmware files for all control components if the components allow for firmware updates
3. Xif files and NXE files for each type of Application Specific device
4. Application files created during project engineering and installation
5. Graphic files created during project engineering and installation
6. Graphic symbol and graphic component library files
7. Data sheets, installation manuals, engineering manuals and operator manuals for all components in the system
8. Application files, graphic files and other files created during engineering of the project that are intrinsic to the system database and can be easily extracted from the database do not have to be separately provided to the owner.

1.11 WARRANTY AND MAINTENANCE

A. All components, system software and parts furnished and installed by the BMS Contractor shall be guaranteed against defects in materials and workmanship for 1 year after substantial completion.

B. Labor to repair, reprogram or replace these components shall be furnished by the BMS contractor at no charge during normal working hours during the warranty period.

C. Materials furnished by not installed by the BMS contractor shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor than originally installed the product.

D. All corrective software, firmware and application modifications made during warranty periods shall be updated on all owner documentation and owner digital files from previous submittals. The intent of this specification is that the BMS contractor will work with the Owner to ensure that what was submitted during post construction submittals is updated to reflect the changes made.

PART 2 - PRODUCTS

2.1 PRE-APPROVED MANUFACTURERS

A. Electric Components: Schneider Electric Field Devices

B. Electronic Components: Schneider Electric Field Devices

C. Direct Digital Control Systems: Schneider Electric

2.2 SYSTEM ARCHITECTURE

A. General

1. The system architecture shall consist of two layers; the WAN/LAN layer and a Field Bus layer. Network Server Controllers are the devices that transition the field bus layer to the WAN/LAN layer. The field bus layer consists of two unique types: FT-10A LON and RS-485 for Modbus RTU, BACnet MSTP and SmartStruxure.
2. WAN/LAN Connected Devices: The following components shall connect to the WAN/LAN.
   a. Network Server Controllers
   b. Enterprise Server Computer
   c. Engineering Workstation Computer
   d. Operator Workstations (Web-Based)
   e. ModBus TCP Controllers
   f. BACnet IP Controller

3. Field Bus Connected Devices: the following components shall connect to one of the field bus types.

   a. Application Specific Devices: FT-10A
   b. Programmable Process Controllers: FT-10A
   c. Supervisory Logic Controllers: FT-10A
   d. Packaged Equipment Modules: FT-10A and/or RS-485
   e. SmartStruxure Controllers: RS-485

4. System Segmentation:

a. System operators and engineers shall be able to connect using workstation software or a web browser to the Enterprise Server and interact with the entire system database in a single presentation.
b. System operators and engineers shall be able to connect using workstation software or a web browser to a single Network Server Controller and interact only with the database in the NSC and the devices on the field bus(s) that connect to the NSC.

5. Standard Network Support:

a. All NSCs, Servers and Workstations shall completely independent of the Owner’s Ethernet TCP/IP LAN/WAN. The DDC system shall reside on a dedicated system and shall not interfere nor interact with the FAA LAN system.

6. System Expansion:

a. The Owner shall have the ability to expand the capacity of the system architecture by adding more NSCs with their associated connected field busses. This process shall not require additional software for the servers or workstations. This expansion capability shall extend to a maximum of 250 Network Server Controllers.
b. The Owner shall have the ability to expand the number of Engineering Workstations with the purchase of additional Workstation software licenses and the purchase of additional engineering tool licenses if simultaneous use of the engineering tools by more than one engineer is desired.

7. Fault Tolerance:

a. The failure of one component within the system architecture shall not cause the entire system to fail. All system users shall be notified by the alarm management system when a component fails.
b. Failure of the Enterprise Server shall not prevent operator connection to any of the Network Server Controllers.
c. Failure of a Network Server Controller shall not negatively affect the Enterprise Server or the other Network Server Controller. The Enterprise Server may no longer present the database from the failed NSC and its subordinate field bus controllers.

8. Operator/Engineer Access:

a. The Enterprise Server shall support the simultaneous connection of up to 30 operators using Workstation or Web Browser software.
b. A Network Server Controller shall support the simultaneous connection of up to 5 operators using Workstation or Web Browser software.
c. The Enterprise Server shall support the simultaneous use of engineering tools by up to 2 engineers connected to the ES. A connection for engineering purposes may also consume one operator connection.
d. A Network Server Controller shall support the use of engineering tools by only one engineer connected to the NSC. A connection for engineering purposes may also consume one operator connection.

9. FT-10A LON Field Bus:

a. The cable shall be unshielded twisted pair, rated for FT-10A use by the supplying vendor, and between AWG20 and AWG24. The same AWG shall be used for the entire field bus. The wiring type and length limitation shall conform to Echelon's Junction Box and Wiring Guideline for Twisted Pair LonWorks Networks.
b. Each segment shall have no more than 55 devices connected excluding the NSC and any repeaters or LON routers.
c. Each segment shall have a termination device installed at both ends.
d. Bus topology is mandatory. No tees, stubs or free topology is allowed.
e. A LON repeater may be installed to add a second segment.
f. A LON to LON router may be connected to the segment that is connected to the NSC to create a multi-channel field bus. All segments in a multi-channel environment must be terminated at both ends. The LON to LON router shall support smart mode and not require commissioning.
g. Specific NSC/Xenta Lon Node Limitations: In addition to the limitation of 55 connected devices per segment, the following limitations must be met.

1) When Xenta controllers are used under a NSC, the total number of connected devices shall not exceed 64 excluding the NSC connection, repeater connections, router connections and expansion IO modules for Xenta programmable process controllers.
2) The number of Xenta programmable process controllers shall not exceed 30. The difference between 64 and the number of Xenta programmable process controllers may be used for Xenta 100s, ASDs and PEMs.
3) Expansion IO modules for Xenta programmable process controllers shall be installed on the same segment as the Xenta programmable process controller they support.

h. The LON outer sheathing shall be yellow in color.

10. RS-485 Field Bus:

a. The cable shall be shielded twisted pair between AWG 20 and AWG 24. The same AWG shall be used for the entire field bus. The cable shall be rated for RS-485 installations by the supplying vendor.

1) Cable Impedance shall be 120 Ohms
2) Cable Capacitance Wire to Shield shall be less than 25 picofarads per foot
3) Cable Capacitance Wire to Wire shall be less than 13 picofarads per foot

b. Device to device, polarity shall be maintained with the same wire always connected to the Data + terminal on each device and the second wire always connected to the Data – terminal on each device.
c. The initial RS-485 field bus shall start at the Network Server Controller.
d. Bus Topology shall be used. No tees or stubs are allowed no matter how short.
e. An RS-485 repeater may be used to extend the overall length of the RS-485 field bus. When a repeater is used, this creates a multi-segment field bus.
f. RS-485 segments shall not be longer than 4,000 feet.

g. The shield shall be continuous over an entire segment. Shield tie terminals on controllers may only be used if they are not connected to earth ground within the controller. If ungrounded tie terminal are not available a wire nut shall be used to keep the shield continuous.

h. The shield shall be connected to earth ground at the NSC. The shield for the initial segment shall not touch earth ground at any other location along the segment. Care shall be taken to ensure no accidental earth ground connections are made within control cabinets.

i. If a RS-485 repeater is used to create a second segment, the shield for the second segment shall be connected to earth ground on the downstream side of the repeater.

j. 120 ohm termination resisters shall be installed at both ends of each segment. The resister shall be connected between the Data + and Data – terminals. Care shall be taken to ensure that the resister leads do not touch earth ground or the shield.

k. The outer cable sheathing shall be color coded as follows:

1) Mod-bus = Purple
2) BacNet = Gray
3) SmartStruxure = Blue
4) SmartStruxure sublan = Orange

11. RS-485 Network Biasing:

a. The contractor shall determine the key characteristics of each controller’s transceiver. This information shall be included in the product submittals. Combinations are:

1) Failsafe, Isolated
2) Failsafe, Non-Isolated
3) Non-Failsafe, Isolated
4) Non-Failsafe, Non-Isolated

b. If “Any One” controller on a segment has a Non-Failsafe transceiver, the segment shall require biasing. If “All” devices on a segment have Failsafe transceivers, the segment shall not require biasing.

c. If a segment requires biasing, it shall be installed at both ends of the segment.

d. For this installation, biasing shall be defined as a 5 VDC floating power supply connected to the Data + and Data – cables through 1,000 ohm resisters. The positive 5 VDC shall be connected to one end of a 1,000 ohm resister. The other end of the resister shall be connected to the Data + terminal. The negative 5 VDC shall be connected to one end of a second 1,000 ohm resister. The other end of this second resister shall be connected to the Data – terminal. By “Floating” power supply, we are referring to the fact that the negative 5 VDC is not connected to earth ground.

e. Cross Connections: Given the connection of communication wire, termination resisters and biasing, it is important to use wiring techniques to ensure that cross connections do not occur between the termination resisters, biasing resisters and shield wires.

12. Controller Loading on an RS-485 network:

a. The contractor shall determine the transceiver unit load and the adapter circuit unit load for each device to be connected to the RS-485 network. This information shall be included with the product submittals. The controller's unit load is the sum of the transceiver unit load and the adapter unit load. In the absence of documented data, the contractor must assign a controller unit load of 1 to a device. Note: Most data sheets only provide the transceiver unit load.

b. The number of controller unit loads that may be installed on a segment is a function of the transceiver characteristics of all of the controllers to be installed.

1) Category A: All of the devices are failsafe and isolated.

a) Total allowed loading is 48 unit loads
b) The NSC consumes 0.5 unit loads leaving 47.5 unit loads for other devices.

2) Category B: All of the devices are failsafe, but one or more of the devices are non-isolated.

a) Total allowed loading is 32 unit loads
b) The NSC consumes 0.5 unit loads leaving 31.5 unit loads for other devices.

3) Category C: All of the devices are isolated, but one or more of the devices are non-failsafe.

a) Total allowed loading is 24.5 unit loads
b) The NSC consumes 0.5 unit loads leaving 24 unit loads for other devices

4) Category D: One or more of the devices are non-failsafe and one or more of the devices are non-isolated.

a) Total allowed loading is 8.5 unit loads.
b) The NSC consumes 0.5 unit loads leaving 8 unit loads for other devices.

13. Isolated Transceiver Devices and the Shield Wire:

a. Unless otherwise directed by a product vendor, when RS-485 controllers with isolated transceivers are installed, the shield shall be connected to the "Reference" terminal on each controller with an isolated transceiver.

b. This connection provides an earth ground reference to the isolated device.

14. Server Limitations for RS-485 Devices:

a. The above limitations are derived from the electrical characteristics of RS-485 communications.

b. System vendors may impose more stringent limitations on the number of RS-485 devices that can be supported by a Network Server Controller or Enterprise Server.

c. The contractor must ensure that system vendor limitations are not exceeded. Under no circumstances shall the installation exceed the limitations based on RS-485 electrical characteristics.

2.3 NETWORK SERVER CONTROLLERS (NSC)

A. Physical Characteristics:

1. Network Server Controllers shall combine routing functions, control functions and server functions in a single integral unit.
2. LAN/WAN: The NSC shall connect to the Owner's LAN/Wan and support communication speeds up to 100 megabits per second.
3. LON Field Bus: The NSC shall connect to a twisted pair FT-10A Lon field bus at 78 kilobits per second.
4. RS-485: The NSC shall have two or more RS-485 ports for the connection of shielded twisted pair cable. Communication speed shall be adjustable between 9600 bits per second and 76.8 kilobits per seconds.
5. SmartStruxure: The NSC shall have the ability to connect to a SmartStruxure RS-485 Controller LAN operating at 19.2 kilobits per second. This is in addition to the two RS-485 ports.
6. Physical IO: By a dedicated physical connection, the NSC shall support the capability to attach multiple physical point expansion modules to allow the NSC to operate as a programmable process controller.

   a. It shall be possible to install IO modules that combine specific point types in order to meet control requirements.
   b. Point Count: The total allowed point count for the IO modules shall not exceed 120.
   c. It shall be possible to replace a specific IO module with a new IO module of the same type without any engineering effort. The new IO module shall automatically begin operation.
   d. All digital outputs shall include integral (not add on) three position manual override switches to allow selection of the ON, OFF, or AUTO mode of operation. The status of these override switches shall automatically be available to the system database.
   e. All analog outputs shall include integral (not add on) two position manual override switches to allow selection of the MANUAL or AUTO mode of operation and override potentiometers to allow a manually set output voltage when the override switch is in the MANUAL mode.
   f. Temperature sensors supported by universal inputs on the physical IO modules shall include the following types.

      1) 10KOhm Type I (Continuum)
      2) 10KOhm Type II (SmartStruxure)
      3) 10KOhm Type III (Satchwell)
      4) 10KOhm Type IV (FD)
      5) Linearized 10KOhm Type V (FD with 11KOhm shunt)
      6) Linearized 10KOhm (Satchwell)
      7) Linearized 1.8KOhm (Xenta)

8) 1 KOhm (Balco)
9) 20 KOhm (Honeywell)
10) 2.2 KOhm (Johnson)

g. The following sensor types shall be supported by IO modules specifically designed to support RTD inputs. Universal inputs do not have to support these types of sensors.

1) PT100 Common Industry RTD Sensor
2) PT1000 Common Industry RTD Sensor
3) Ni1000 Sauter RTD Sensor
4) Siemons LG-Ni1000 RTF Sensor

h. RTD Sensor Inputs shall support both two wire and three wire installation techniques.

1) The input and output circuits must meet the requirements defined for programmable process controllers.

i. Configuration Cable: The NSC shall have a cable port to provide connectivity to a laptop USB port for assigning the IP address and changing the firmware.
j. Power Supply: The NSC shall be provided with a custom power supply unit to power the NSC and the physical point expansion modules. The power supply unit shall use 24 VAC in either full wave or half wave configuration and create 30 Watts of power at 24 VDC for the NSC and IO modules. When the total load of the NSC and IO modules exceeds 30 Watts, a second power supply may be installed in series with the IO modules to provide additional power.
k. LEDs: The NSC shall have LED indication for CPU status, Ethernet LAN status and field bus status.
l. Real Time Clock: The NSC shall have a real time clock with battery backup accurate to 10 seconds per day.

1) Information provided shall include time of day, day, month, year and day of week.
2) The UTC offset shall be adjustable to establish a specific time zone for the NSC.
3) Standard or custom daylight saving time configuration shall be possible.

m. FLASH Memory Storage: The operating system of the NSC, application programs and all other portions of the database shall be stored in non-volatile, FLASH memory.
n. Free Memory: With the system in full operation, the NSCs shall have 20% free memory.
o. Device Memory: The NSC shall have an available capacity of 4 GB of memory. This shall represent 2 GB for application and historical data and 2 GB dedicated for the storage of a backup file.

B. Performance

1. Restoration After Power Outage: Upon restoration of power after an outage, the NSC shall automatically and without human intervention update all monitored functions, resume operation based on the current synchronized time and status and implement special start-up strategies as programmed.
2. Battery Backup: The battery shall provide accumulated backup of all RAM and clock functions for at least 30 days. In the case of a power failure, the NSC shall first try to restart from the RAM memory. If that memory is corrupt or unusable, then the NSC shall restart itself from its application program stored in its FLASH memory.
3. FLASH Memory: The operating system of the NSC, application programs and all other configurable database objects such as graphics, trends, alarms, views etc. shall be stored in non-volatile FLASH memory.
4. Applications in the Network Server Controllers shall monitor the Network Server Controller input points and control the Network Server Controller output points.
5. Applications in the Network Server controllers shall monitor data from field bus controllers, execute applications using that data and send commands and/or parameters to field bus controllers.
6. Control Programs: Control programs shall be freely programmable by an application engineer from a defined mathematical tool set. Multiple programs shall process in parallel with all programs executing simultaneously. Any program may affect the operation of any other program via data flow from program to program. Each program shall have the full access of all IO facilities of the processor. The execution of control functions shall not be interrupted due to normal user communications including interrogation, program entry, printing or saving. The scan rate for control programs shall be adjustable and must include settings of 0.5 seconds, 1.0 second, 5 seconds and 10 seconds.
7. The Network Server Controller shall host graphics, trend logs, charts, alarm views and other similar presentation objects that can be served to operator workstations or web-based operator workstations.
8. The Network Server Controller shall be capable of executing the following functions:

   a. Calendar based time schedules
   b. Recurring time based schedules
   c. Holiday based schedules
   d. Trending based on adjustable time intervals
   e. Trending based on change of state or value
   f. Alarm condition monitoring
   g. Alarm message routing
   h. Time synchronization by means of an Internet site including automatic synchronization
   i. Native integration of data from LON field bus controllers
   j. Native integration of BACnet data from BACnet field bus controllers
   k. Native integration of Modbus data from Modbus field bus controllers
   l. Native integration BACnet data from BACnet IP devices
   m. Native integration of Modbus data from Modbus IP devices
   n. Native integration of data from IP devices using Web Services.

9. The Network Server Controller shall execute LonWorks Network Management functions.

   a. Assign domain number, subnet numbers and node numbers to LON field bus controllers.

b. Establish LON bindings between the Network Server Controller and LON field bus controllers.
c. Establish LON bindings between two field bus controllers.
d. Assign a Binding Service type to all LON bindings.

C. User Programming Language

1. Control programs in the Network Server Controller shall be user programmable. An application engineer shall be able to create multiple programs to meet specified control sequences.
2. Output data from one program shall be able to be input data to a second program.
3. The Network Server Controller shall support the use of a script-based structured text application programming tool and a graphical object oriented application programming tool.
4. The application engineer shall be able to add comments anywhere in the body of either script or graphical function block programs.
5. Inputs to programs shall include:

    a. Status of physical input points
    b. Values from the database
    c. Status of time schedules
    d. User adjustable parameters

6. Outputs from the programs shall include

    a. Commands to physical output points
    b. Data to Software Points in the database

7. The values of inputs and outputs to programs shall be viewable by the operator.
8. It shall be possible to create viewable values within the programs. As an example, a program may have multiple room temperatures as inputs. The program calculates the average temperature and uses the average temperature within the program as part of an algorithm to create an output from the program. It shall be possible for the operator to view the average temperature value.
9. The following algorithms shall be integral to the application programming software.

    a. Proportional, Integral plus Derivative Control

        1) Ziegler Nichols model
        2) Velocity Form of the PID Model

    b. Two position control with hysteresis (deadband)

        1) Direct acting
        2) Reverse acting

    c. Digital Filtering
    d. Rolling Average Analog Filtering for stability
    e. Ratio Calculations (Reset Schedule) with output limit control
    f. Time Delay On

g. Time Delay Off
h. Mathematical limits
i. Sample and hold
j. Latching with reset
k. Minimum On Time
l. Minimum Off Time
m. Curve fitting with up to 64 points on the curve
n. Horner Scheme Polynomial function with support for up to 64 coefficients
o. Enthalpy function supporting imperial units
p. Time functions (second, minute, hour, day of week, day of month)
q. Integration
r. Runtime
s. Timed pulses
t. Basic mathematical functions (addition, subtraction, multiplication, division, powers, square root, logarithms, Boolean logic, greater than, less than, equal to, exclusive or, if-then-else, etc.)
u. Mathematical expressions shall support nesting of parentheses five levels deep.

D. Energy Management Routines

1. With standard database objects and application programs, the following energy management routines shall be supported.

a. Time of Day Scheduling
b. Calendar Based Scheduling
c. Holiday Scheduling
d. Temporary Schedule Overrides
e. Optimal Start
f. Optimal Stop
g. Night Setback Control
h. Night Setup Control
i. Unoccupied Purge Mode
j. Peak Demand Limiting
k. Temperature Compensated Duty Cycling
l. CFM Tracking for Dual Fan VAV Systems
m. Static Pressure Set Point Reset as a function of VAV terminal unit performance
n. Supply Air Temperature Set Point Reset as a function of VAV terminal unit performance
o. Water (Hydronic) flow reset as a function of system differential pressure.

E. Historical Data Logging (Trend Logs)

1. A trend log is defined as the original logging of an element of data over time based on a fixed time interval or a change of value or state.
2. An extended trend log is defined as a log at a higher level in the system architecture where the log data from a trend log or lower level extended trend log is periodically transferred. Extended trend logs will have a larger number of records allowed for long term data storage.
3. Logging Concepts

a. A field bus controller supports logging. A trend log exists in a field bus controller. An extended trend log exists in the Network Server Controller and the trend log data from the field bus controller is periodically uploaded. An extended trend log exists in the Enterprise Server (Computer) and the trend log data from the extended trend log in the Network Server Controller is periodically uploaded.
b. A field bus controller does not support logging. Data from the field bus controller is mirrored in the Network Server Controller. A trend log is established in the Network Server Controller to trend the mirrored data. An extended trend log exists in the Enterprise Server (Computer) and the trend log data in the Network Server Controller is periodically uploaded.
c. Data in a field bus controller may be directly trended by the Network Server Controller bypassing the mirrored data concept provided that the type of trend logging is time based and the time interval is ten minutes or greater. The contractor must ensure that the use of this concept does not create excessive bandwidth utilization due to a large number of variables being trended. For a Lon field bus, an average bandwidth utilization of 30% is considered excessive.

4. Logging Criteria

a. Time intervals of 1 second to 1440 seconds must be supported.
b. For change of value trend logs, the delta must be adjustable.
c. The raw logged data must be instantaneous. The presentation of the data must include the following automatic calculations to the raw data.

1) Maximum
2) Minimum
3) Average
4) Sum
5) Delta
6) Meter Consumption (for meter logs)

5. With respect to Trend Logs, the Network Server Controller shall support:

a. 1,000 trend logs
b. 1,500 extended logs
c. 100,000 records for a trend log
d. 600,000 records for an extended log
e. 3,800,000 total log records (trend logs and extended logs)

6. Transferring logged data form a lower level in the architecture to a higher level in the architecture shall be based on one of the following. All options must be available to the operator.

a. Manual command to upload
b. Defined time period
c. Percentage of logged space filled

7. Trends shall be set up by the contractor for all temperature & set points, valve command/feedback, any enable/status, speed/feedback, damper positions and any other data points that are pertinent to troubleshooting.

F. Historical Data Presentation (Trend Charts and Trend Lists)

1. Trend charting capability shall exist in the Network Server Controllers and the Enterprise Server.
2. Trend list capability shall exist in the Network Server Controllers and the Enterprise Server.
3. Trend lists shall display data in a time stamped list format.
4. Trend charts shall support configurable pen colors, configurable line weights, two adjustable scales and adjustable time spans.

G. Alarm Management

1. Alarm objects shall monitor data that exists in the Network Server Controller or the Enterprise Server. If the data that needs to be monitored exists in a field bus controller, the data shall be mirrored in the Network Server Controller, using event driven factors such as send on delta (COV), minimum send time and maximum send time to manage bandwidth utilization. The alarm object shall then monitor the mirrored data.
2. Types of Alarm Monitoring

   a. Monitored data changes state
   b. Monitored data matches a specific integer
   c. Monitored data is outside of a specific range of value, either above or below
   d. Monitored data is not within a specified range of a second monitored value, either above or below
   e. Monitored data text string does not match a specified text string
   f. Sum Alarms: Multiple alarm conditions must be met

3. Data Monitoring by Alarm Objects

   a. Data in the Network Server Controllers or the Enterprise Server shall be monitored no less than twice a second.

4. Alarm messages shall be presented to the users in a fully configurable order, by priority, by time, by category, etc. These configurable alarm lists shall be presented to the user upon logging into the system from either the Workstation or a Web Browser.
5. The alarm management shall support the ability to create and select cause and action notes to be selected and associated with an alarm event. Checklists shall also be possible in order to present to an operator a suggested mode of troubleshooting. When acknowledging an alarm, it shall be possible to assign it to a specific user of the system such that the specific user is notified of the assignment and is made responsible for the alarm resolution.
6. Alarm Objects in Field Bus Controllers may be used if they are compatible with the workstation alarm management system and there is no loss of capability.

H. Embedded Web Server

1. Each Network Server Controller shall have the ability to serve out web pages containing the same information that is available from the Workstation presentation. The development of the screens to accomplish this shall not require any additional engineering labor over that required to show them via the Workstation presentation.

I. Network Server Controller Configuration

1. Configuration shall be possible without the use of an operable IP network via a cross over cable.
2. Optionally a direct connect proprietary cable may be used to assign an initial IP address and load firmware.
3. Once a Network Server Controller has an IP address that is compatible with the IP network and the IP network is operational, configuration shall be possible via the IP network.

J. Network Server Controller to Network Server Controller Communication

1. A Network Server Controller shall have the ability to poll for data from a second Network Server Controller.

    a. The polling rate shall be adjustable at 1 second, 5 seconds or 10 seconds.

2. A Network Server Controller shall be able to request data from up to ten other Network Server Controllers.
3. A Network Server Controller shall be able to respond to requests for data from up to 64 other Network Server Controllers.
4. Data being transferred from Network Server Controller to Network Server Controller shall be positioned as values in the Network Server Controller database.

    a. Data that originates in a Lon field bus controller shall be transferred to its hosting Network Server Controller via a Lon binding to a Lon network variable on the Network Server Controller.
    b. This data shall then be transferred to a value in the Network Server Controller for subsequent transfer to a second Network Server Controller.

K. Supervisory Logic Support for Field Bus Controllers

1. The Network Server Controller shall provide supervisory logic support for the Lon field bus controllers on its sub-ordinate FT-10A Lon field bus.
2. Data required as input to supervisory logic shall be transferred to the Network Server Controller via a Lon binding to a Lon network variable on the Network Server Controller.
3. Application programs in the Network Server Controller shall read the transferred values, execute the programmed algorithms and send commands and values to outbound network variables on the Network Server Controller.
4. These outbound network variables shall then be transferred to the Lon field bus controllers via Lon bindings.
5. Appropriate values for send on delta, min send time and max send time parameters shall be used to maintain reasonable bandwidth utilization (Average Bandwidth Utilization Less Than 30%).

L. Time Based Control for Applications in Field Bus Controllers

1. Time schedules, standard and optimized, shall reside in the Network Server Controllers.
2. Occupancy commands shall be sent to an outbound network variable on the Network Server Controller.

3. The outbound network variables shall then be transferred to the Lon field bus controllers via Lon bindings.

2.4 PHYSICAL LAYER REPEATERS (PLR)

A. PLRs are required to connect two segments of the FT-10A field bus.

B. The design of the PLRs shall conform to LonMark Standards.

C. Lon to Lon routers configured as repeaters may be used to perform as a PLR. If configuration of the Lon to Lon router requires a third party configuration tool such as LonMaker for Windows or NL220, then the Lon to Lon router may not be used. The configuration of the device must be via on-board dip switches.

2.5 LON TO LON ROUTERS

A. Lon to Lon routers may be used to add a second channel to the FT-10A field bus.

B. The field bus architecture shall be designed such that any field bus controller has a maximum of one Lon to Lon router between it and the Network Server Controller.

C. Lon to Lon routers must operate in a Learning mode and not require commissioning by a third party network management tool such as LonMaker for Windows or NL220. Configuration as a Learning Router shall not require any software tool.

2.6 LON FIELD BUS DEVICES

A. General Requirements

1. Devices shall incorporate a service pin which, when pressed, will cause the device to broadcast its 48 bit node ID and its program ID over the network. The service pin shall be distinguishable and accessible.
2. Devices shall have a light indicating that they are powered.
3. Devices shall incorporate a TP/FT-10A transceiver in accordance with ANSI/EIA 709.3 and connections for TP/FT control network wiring.
4. Devices shall be locally powered. Link powered devices are not acceptable.
5. Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings.

B. Programmable Process Controller (PPC)

1. The key characteristics of a PPC are:

a. They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output devices and binary output devices. The number and type of input and output devices supported will vary by model.
b. They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support

for additional I/O may be by additional circuit boards that physically connect to the basic controller or by a stand-alone device that communicates with the basic controller via the FTT-10A field bus.

c. The application to be executed by a PPC is created by an application engineer using the vendor's application programming tool.
d. PPCs shall support embedded time schedules for use when the controller has lost communication with the NSC. The Network Server Controller will provide time schedule support for the PPC applications.
e. PPCs shall support trend data storage with periodic upload to extended trend logs in the NSC. Trend logging for up to 50 variables shall be supported.
f. PPCs shall support the initiation of an alarm message to the NSC

2. Analog Input Circuits

a. The electrical signals from analog sensors shall be processed by an analog to digital (A/D) converter chip. The output of the A/D chip shall then be processed mathematically to produce data within the controller that has the required engineering units.
b. The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
c. For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).
d. For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values determined by a calibration instrument).
e. For non-linear sensors such as thermistors and flow sensors the PPC shall provide software support for the linearization of the input signal.

3. Digital Outputs

a. All digital outputs shall have a status (feedback) input directly related to the respective output.
b. Each feedback shall be graphically displayed on the appropriate graphics page(s).

4. Binary Input Circuits

a. Dry contact sensors shall wire to the controller with two wires.
b. An external power supply in the sensor circuit shall not be required.

5. Pulse Input Circuits

a. Pulse input sensors shall wire to the controller with two wires.
b. An external power supply in the sensor circuit shall not be required.
c. The pulse input circuit shall be able to process up to 50 pulses per second.

6. True Analog Output Circuits

a. The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
b. The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.

7. Pulse Width Modulation Outputs with PWM transducers

a. The controller shall be able to generate incremental pulses as small as 0.1 seconds.

8. Binary Output Circuits

a. Single pole single throw or single pole double throw relays with support for up to 230 VAC and a maximum current of 2 amps.
b. Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.8 amps.

9. Application Programming Software

a. Application programming shall be accomplished using a graphical object oriented tool.
b. The following algorithms shall be integral to the application programming software.

1) Proportional, Integral plus Derivative Control

a) Ziegler Nichols model
b) Velocity Form of the PID Model

2) Two position control with hysteresis (deadband)

a) Direct acting
b) Reverse acting

3) Digital Filtering
4) Rolling Average Analog Filtering for stability
5) Ratio Calculations (Reset Schedule) with output limit control
6) Time Delay On
7) Time Delay Off
8) Mathematical limits
9) Sample and hold
10) Latching with reset
11) Minimum On Time
12) Minimum Off Time
13) Curve fitting with up to 64 points on the curve
14) Horner Scheme Polynomial function with support for up to 64 coefficients
15) Enthalpy function supporting imperial units
16) Time functions (second, minute, hour, day of week, day of month)

17) Integration
18) Runtime
19) Timed pulses
20) Basic mathematical functions (addition, subtraction, multiplication, division, powers, square root, logarithms, Boolean logic, greater than, less than, equal to, exclusive or, if-then-else, etc.)
21) Mathematical expressions shall support nesting of parentheses five levels deep.

10. Program Execution

a. Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
b. The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
c. The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
d. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
e. The application shall have the ability to determine if a power cycle to the controller has occurred, and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.
f. Local Interface: The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:

1) Adjust application parameters.
2) Edit time schedule parameters if time schedules are embedded in the controller.
3) Execute manual control of input and output points.
4) View dynamic data.
5) View alarm messages if alarm messaging is embedded in the controller.

11. Each PPC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

C. Supervisory Logic Controller (SLC)

1. Supervisory logic shall be located in the Network Server Controller unless special application requirements require the use of a SLC. If SLCs are required, the following requirements apply.

2. The key characteristics of an SLC are:

a. The application to be executed by as SLC is created by an application engineer using the vendor's application programming tool.

b. SLCs shall support embedded time schedules for use when the controller loses communication with the NSC.
c. SLCs shall support trend data storage with periodic upload to extended trend logs in the NSC. Trend logs for up to 50 variables shall be supported.

3. Application Programming Software

a. The requirements for the application programming tool used to create applications in a SLC are identical to those described for a Programmable Process Controller.

4. SLCs shall support the initiation of an alarm message to the NSC.
5. Program Execution

a. Control algorithms shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
b. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
c. The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.

6. Local Interface: The controller shall support the connection of a interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:

a. Adjust application parameters.
b. Edit time schedule parameters if time schedules are embedded in the controller.
c. Execute manual control of input and output network variables.
d. View dynamic data.
e. View alarm messages if alarm messaging is embedded in the controller.

7. Each SLC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.
8. Supervisory logic controllers shall have support a minimum of 200 input network variables and 70 output network variables.

a. The SNVT for each of the 200 input network variables shall be selectable.
b. The SNVT for each of the 70 output network variables shall be selectable.
c. For the input and output network variables there shall not be any limitations as to the SNVT selected. (Example: SNVT_temp_p can only be used on 10 input network variables.)

9. Application Specific Devices (ASD)

a. ASD shall have fixed function configurable applications.
b. If the application can be altered by the vendor's application programming tool, the device is a programmable controller and not an application specific device. A

c. All input and output network variables shall be formatted with SNVTs.

d. All input configuration parameters shall be formatted with SNVTs or SCPTs. If UNVTs or UCPTs are used, the device resource files that allow these custom parameters to be read shall be provided to the owner.

e. The network interface shall conform to the LonMark profile for the application provided by the ASD.

f. Each ASD shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

2.7 DDC SENSORS AND POINT HARDWARE

A. Temperature Sensors

1. Known acceptable source: Veris Industries
2. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F. Space temperature sensors shall be accurate to +/-0.5 degrees F over a range of 40 to 100 degrees F.
3. Room Sensor: Standard space sensors shall be available in an off white enclosure made of high impact ABS plastic for mounting on a standard electrical box. Basis of Design: Veris TW Series.

    a. Where manual overrides are required, the sensor housing shall feature both an optional sliding mechanism for adjusting the space temperature setpoint, as well as a push button for selecting after hours operation.

    b. Where a local display is specified, the sensor shall incorporate an LCD display for viewing the space temperature, setpoint and other operator selectable parameters. Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.

4. Duct Probe Sensor: Sensing element shall be fully encapsulated in potting material within a stainless steel probe. Useable in air handling applications where the coil or duct area is less than 14 square feet. Basis of Design: Veris TD Series.
5. Duct Averaging Sensor: Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube shall contain at least one thermistor for every 3 feet, with a minimum tube length of 6 feet. The averaging sensor shall be constructed of rigid or flexible copper tubing. Basis of Design: Veris TA Series.
6. Pipe Immersion Sensor: Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Provide sensor probe length suitable for application. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications. Basis of Design: Veris TI Series.
7. Outside Air Sensor: Provide the sensing element on the building's north side. Sensing element shall be fully encapsulated in potting material within a stainless steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure. Operating range -40 to 122 Deg. F, Basis of Design: Veris TO Series.
8. A pneumatic signal shall not be allowed for sensing temperature.

B. Humidity Wall Transmitters

1. Known acceptable source: Veris Industries.
2. Transmitters shall be accurate to +/- 1 % at full scale.
3. Transmitter shall have replaceable sensing element.
4. Sensor type shall be thin-film capacitive.
5. Sensor element shall contain multipoint calibration on-board in nonvolatile memory.
6. Operating range shall be 0 - 100% RH noncondensing, 50 to 95 Deg. F.
7. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC.
8. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
9. Transmitter shall be available in an off white enclosure made of high impact ABS plastic for mounting on a standard electrical box.
10. Transmitter shall have LCD display.
11. Transmitter shall be available with a certification of NIST calibration.
12. Transmitter shall have integrated temperature sensor.
13. Basis of Design: Veris HWL Series.

C. Humidity Duct Transmitters

1. Know acceptable source: Veris Industries.
2. Transmitters shall be accurate to +/- 2 % at full scale.
3. Transmitter shall be fully encapsulated in potting material within a stainless steel probe.
4. Transmitter shall have replaceable sensing element.
5. Sensor type shall be thin-film capacitive.
6. Sensor element shall contain multipoint calibration on-board in nonvolatile memory.
7. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 Deg. F.
8. Output shall be 4-20 mA or 0-5/0-10 VDC.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
10. Transmitter shall be available with a certification of NIST calibration.
11. Transmitter shall have integrated temperature sensor.
12. Basis of Design: Veris HD Series.

D. Humidity Outdoor Transmitters

1. Known acceptable source: Veris Industries.
2. Transmitters shall be accurate to +/- 2% at full scale.
3. Transmitter shall be fully encapsulated in potting material within a stainless steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure.
4. Transmitter shall have replaceable sensing element.
5. Sensor type shall be thin-film capacitive.
6. Sensor element shall contain multipoint calibration on-board in nonvolatile memory.
7. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 Deg. F.
8. Output shall be 4-20 mA or 0-5/0-10 VDC.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
10. Transmitter shall be available with a certification of NIST calibration.
11. Transmitter shall have integrated temperature sensor.
12. Basis of Design: Veris HO Series.

E. Air Pressure Transmitters

1. Known acceptable source: Veris Industries.
2. Sensor shall be microprocessor profiled ceramic capacitive sensing element.
3. Transmitter shall have 14 selectable ranges from 0.1 – 10” WC.
4. Transmitter shall be +/- 1% accurate in each selected range including linearity, repeatability, hysteresis, stability, and temperature compensation.
5. Transmitter shall be field configurable to mount on wall or duct with static probe.
6. Transmitter shall be field selectable for Unidirectional or Bidirectional.
7. Maximum operating pressure shall be 200% of design pressure.
8. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC linear.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
10. Response time shall be field selectable T95 in 20 seconds or T95 in 2 seconds.
11. Transmitter shall have an LCD display.
12. Units shall be field selectable for WC or PA.
13. Transmitter shall have provision for zeroing by pushbutton or digital input.
14. Transmitter shall be available with a certification of NIST calibration.
15. Basis of Design: Veris model PXU.

F. Liquid Differential Pressure Transmitters

1. Known acceptable source: Veris Industries.
2. Transmitter shall be microprocessor based.
3. Transmitter shall use two independent gauge pressure sensors to measure and calculate differential pressure.
4. Transmitter shall have 4 switch selectable ranges.
5. Transmitter shall have test mode to produce full-scale output automatically.
6. Transmitter shall have provision for zeroing by pushbutton or digital input.
7. Transmitter shall have field selectable outputs of 0-5V, 0-10V, and 4-20mA.
8. Transmitter shall have field selectable electronic surge damping.
9. Transmitter shall have an electronic port swap feature.
10. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
11. Sensor shall be 17-4 PH stainless steel where it contacts the working fluid.
12. Performance:

    a. Accuracy shall be ±1% F.S. and ±2% F.S. for lowest selectable range.
    b. Long term stability shall be ±0.25%.
    c. Sensor temperature operating range shall be -4° to 185°F.
    d. Operating environment shall be 14° to 131°F; 10-90% RH noncondensing.
    e. Proof pressure shall be 2x max. F.S. range.
    f. Burst pressure shall be 5x max. F.S. range.

13. Transmitter shall be encased in a NEMA 4 enclosure.
14. Enclosure shall be white powder-coated aluminum.
15. Transmitter shall be available with a certification of NIST calibration.
16. Basis of Design: Veris PW.

G. Current Sensors

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in split core models, and offer either a digital or an analog signal to the automation system. Known acceptable source is Veris Industries.

H. Current Status Switches for Constant Load Devices

1. Known acceptable source: Veris Industries.
2. General: Factory programmed current sensor to detect motor undercurrent situations such as belt or coupling loss on constant loads. Sensor shall store motor current as operating parameter in non-volatile memory. Push-button to clear memory.
3. Visual LED indicator for status.
4. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms. Sensor shall indicate status from 0.5 A to 175 A.
5. Normally open current sensor output. 0.1A at 30 VAC/DC.
6. Basis of Design: Veris Model H608.

I. Current Status Switches for Constant Load Devices (Auto Calibration)

1. Know acceptable source: Veris Industries.
2. General: Microprocessor based, self-learning, self-calibrating current switch. Calibration-free status for both under and overcurrent, LCD display, and slide-switch selectable trip point limits. At initial power-up automatically learns average current on the line with no action required by the installer.
3. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms. Sensor shall indicate status from 2.5 A to 200 A.
4. Display: Backlit LCD; illuminates when monitored current exceeds 4.5A.
5. Nominal Trip Point: ±40%, ±60%, or on/off (user selectable).
6. Normally open current sensor output. 0.1A at 30 VAC/DC.
7. Basis of Design: Veris Model H11D.

J. Current Status Switches for Variable Frequency Drive Application

1. Known acceptable source: Veris Industries.
2. General: Microprocessor controlled, self-learning, self-calibrating current sensor to detect motor undercurrent and overcurrent situations such as belt loss, coupling shear, and mechanical failure on variable loads. Sensor shall store motor current as operating parameter in non-volatile memory. Push-button to clear memory and relearn.
3. Visual LED indicator for status.
4. Alarm Limits: ±20% of learned current in every 5 Hz freq. band.
5. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms. Sensor shall indicate status from 1.5 A to 150 A and from 12 to 115 Hz.
6. Normally open current sensor output. 0.1A at 30 VAC/DC.
7. Basis of Design: Veris Model H614.

K. Liquid Flow, Insertion Type Turbine Flowmeter

1. Known acceptable source: Veris Industries.
2. General: Turbine-type insertion flow meter designed for use in pipe sizes 1 1/2” and greater. Available in hot tap configuration with isolation valves and mounting hardware to install or remove the sensor from pipeline that is difficult to shut down or drain.
3. Performance:

    a. Accuracy: ±1% of rate over optimum flow range; ≥10 upstream and ≥5 downstream straight pipe diameters, uninterrupted flow.

b. Repeatability: ±0.5%.
c. Velocity Range: 0.3 to 20 FPS.
d. Pressure Drop: 0.5 psi or less @ 10 ft/sec for all pipe sizes 1.5” diameter and up.
e. Pressure Rating: 1000 psi @ 70°F.

4. Maximum Temperature Rating: 300°F.
5. Materials: Stainless Steel or Brass body; Stainless steel impeller.
6. Transmitter:

a. Power Supply: 12 - 30VAC or 8 - 35VDC.

1) Output: Frequency, 4-20 mA or Scaled Pulse.

b. Temperature Range: 14° to 150°F.
c. Enclosure: NEMA 4, Polypropylene with Viton® sealed acrylic cover.

7. Basis of Design: Veris SDI series.

L. Control Valves

1. Provide automatic control valves suitable for the specified controlled media (water or glycol). Provide valves which mate and match the material of the connected piping. Equipment control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
2. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.
3. All control/bypass valves shall be Belimo Energy Valves and shall meet the following:

a. Pressure independent control valves (Water Coil Optimization).
b. NPS 2” and smaller: Forged brass body rated at no less than 250 psi, stainless steel ball and stem female NPT union ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc.
c. NPS2-1/2” through 6”: GG25 cast iron body according to ANSI Class 125, Standard Class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.
d. Accuracy: Control valves shall accurately control the flow from 0 to 100% of the rated flow with an operating pressure differential range of 5 to 50 psi differential across the valve with a valve body flow accuracy of =/- 5 total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.
e. Flow Characteristics: Equal percentage characteristic.
f. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
g. Water coil optimization shall be accomplished by utilizing a pressure independent control valve assembly; two temperature sensors providing feedback of coil inlet

and outlet water temperatures; and an electronic flow meter to provide analog flow feedback. Software shall control the valve to avoid the coil differential temperature from falling below a programmed set point, the valve assembly shall be capable of accepting an analog signal representing the coil power required. Real-time data and configuration of valve operating parameters shall be available by means of BACnet MS/TP, BACnet/IP or HTTP. Monitored points shall include, but not be limited to inlet and outlet coil water temperatures, absoluteflow, absolute valve position, absolute coil power and total heating/cooling energy in BTU/hr. Configuration points shall include but not be limited to valve, flow, and power settings. Historical trend data shall be stored for up to 13 months and be retrievable in a standard time-stamped format.

h. The manufacturer shall provide a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).
i. A wet calibrated electronic flow meter shall provide dynamic feedback to measure flow and verify performance.
j. The control valve shall require no maintenance and shall not include replaceable cartridges.
k. Known Acceptable Source: Belimo EV050s-055=LRX24-EV.

4. Electric actuation should be provided on all terminal unit reheat applications unless electric heat is provided.

M. Damper Actuators

1. Damper actuators shall be electronic, and shall be direct coupled over the shaft, without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

N. Actuators (General)

1. All actuators (dampers, valves, etc.) shall have duel status switches.
2. Known Acceptable Source: Belimo AFB24-S.

O. Smoke Detectors

1. Air duct smoke detectors shall be provided by the fire alarm contractor. Detectors shall be installed by the mechanical contractor and wired by the fire alarm contractor.

P. Airflow Measuring Stations

1. Provide a thermal anemometer using instrument grade self –heated thermistor sensors with thermistor temperature sensors.
2. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.

2.8 ENTERPRISE SERVER HARDWARE

A. Processor

1. Minimum of 2.0 GHz
2. Recommended at 2.6 GHz or higher.

B. Memory

1. Minimum of 4 GB
2. Recommended at 4 GB or higher

C. Operating System shall conform to system vendor requirements. When the vendor supports multiple systems, the most current system shall be used:

1. Microsoft Windows 8.1, or
2. Microsoft Windows 10, most current

D. 10/100 MBPS Ethernet NIC

E. 250 GB Hard Disk as a minimum

F. Read/Write DVD Drive

G. License agreement for all applicable software

H. Third Party Software: All third party software required for a fully operational system shall be provided and licensed. Example: Microsoft Office

2.9 WORKSTATION HARDWARE AND SYSTEM SOFTWARE

A. Processor

1. Minimum of 1.0 GHz
2. Recommended at 2.0 GHz or higher

B. Memory

1. Minimum of 4 GB
2. Recommended at 4 GB or higher

C. Operating System shall conform to system vendor requirements. When the vendor supports multiple systems, the most current system shall be used:

1. Microsoft Windows 7 Pro 32-bit, or
2. Microsoft Windows 7 Pro 64-bit, or
3. Microsoft Windows 8.1, most current

D. 10/100 MBPS Ethernet NIC

E. 250 GB Hard Disk as a minimum

F. Read/Write DVD Drive

G. License agreement for all applicable software

H. Third Party Software: All third party software required for a fully operational system shall be provided and licensed. Example: Microsoft Office

2.10 WEB-BASED OPERATOR WORKSTATION HARDWARE AND SYSTEM SOFTWARE

A. Any user on the network shall be able to access the Enterprise Server or any NSC by using the following software:

1. Windows XP or Windows 7 Operating System
2. Google Chrome
3. Firefox 4.0, 32-bit and above
4. Internet Explorer 10, 32-bit and above

2.11 WORKSTATION/SERVER REQUIREMENTS

A. General

1. Provide one (1) Enterprise Server.

a. Provide access for 10 web based operators and 2 workstation based engineering/operator users concurrently

2. Provide one (1) Operator Work Station

B. Databases

1. The Enterprise Server and Network Server Controllers shall hold the databases.
2. When an operator connects to the Enterprise Server, all databases shall be accessible (the ES database and one Db for each NSC).
3. When an operator connects to a specific NSC, only the database in that NSC shall be accessible.
4. The workstation software shall allow any user with adequate permission to create and/or modify any or all parts of a database. These changes are recorded within the databases and not on the operator workstation. When two operators are connected to a database, a change made by one operator will automatically be viewable by the second operator.

C. Workstation Software shall include as a minimum:

1. Programming editors
2. Configuration editors
3. Graphics creation editor
4. Object creation editors (points, values, folders, programs, charts, lists, views, bindings, etc.)

5. Alarm viewing
6. Event viewing
7. Trend data presentation
8. Graphics viewing

D. General Administration and Programming Workstation Software

1. The system architecture shall be client server in that the Workstation shall operate as the client while the ES or NSC shall operate as the servers. The server is responsible for data gathering, data storage and data delivery to clients. The client is responsible for data presentation to the user and delivery of user instructions to the server databases.
2. Workstation functions shall include:

    a. Monitoring data from the ES, NSCs and Field Bus Controllers
    b. Programming the ES database, the NSC databases and the Field Bus Controller applications.
    c. Configuring Application Specific Devices
    d. Viewing and managing alarms
    e. Viewing and managing events
    f. Viewing graphic displays
    g. Viewing collected data (trend logs, extended logs)
    h. Schedule and set point adjustments
    i. Executing operator overrides of applications

3. Programmable Field Bus Controllers

    a. The engineer shall be able to program a PPC either off-line or on-line.
    b. All data from the PPCs shall be available in graphic or text displays in the NSC.

4. Graphic displays will:

    a. Feature animation effects to indicate the status or values associated with systems.
    b. Alert operators of problems.
    c. Facilitate location of information throughout the system.

5. Operator Interaction
    a. All operator functions shall be selectable through the use of a mouse to the maximum extent possible.

E. User Interface

1. The workstation software shall allow the creation of a custom, browser-style interface linked to each individual user that logs into the system.
2. It shall be possible to create customized workspaces that can be assigned to a specific collection of users (user groups).
3. The user interface will support the creation of hot spots or links to all objects or software tools that are appropriate for the given user. This interface will be the user's "PC Desktop".

4. The system administrator shall be able to limit what a specific user can see or do with respect to the workstation and the database.

a. A user that is not associated with a central system might not be given rights to access the system data or see the alarms associated with the system.
b. A user might be given rights to view data but not control data for specific portions of the database.

5. The BAS system shall automatically use the units (SI or Imperial) that are associated with the regional setting of the PC.

F. User Security

1. The software shall provide for each user to have a unique username and password.
2. The software shall provide that a collection of users may be assigned to a user group that will be assigned identical capabilities within the system.
3. Users and User Groups shall be linked to a set of capabilities with the software, set by and editable only by, a system administrator.
4. The sets of capabilities shall range from View Only, Acknowledge Alarms, Enable/Disable, Change Values, Edit Programs and Administer.
5. The system shall allow the range of capabilities to be applied to each class of database object.
6. The capacity of the system must allow for up to 256 Users or User Groups to be established.
7. The system shall provide the ability to add or remove users based on Microsoft Windows Security Domains such that the customer IT department can assist in controlling user access.

G. Configuration Interface

1. The workstation software shall use a Windows Explorer style interface for an operator or engineer to view and/or edit any database object in the entire system.
2. The NSCs and Field Bus Controllers shall be presented in an organized tree structure. With each NSC or Field Bus Controller, the related points, programs, alarms, trends, charts shall be included for easy identification of the relationship of the objects to the controller.
3. All object names shall be alphanumeric and use Windows long filename conventions.
4. The tree structure shall support the use of folders to organize database objects by type or system.
5. It shall be possible to export individual objects, devices or a collection of objects creating a “library” that can then be imported for redundant use within the original database or imported in a new database.
6. The database shall support the use of copy/paste for engineering efficiency.
7. The engineer shall have the ability to mass edit a collection of like objects.
8. When one object type is created from a second object type, the engineer shall have the ability to mass create the new objects from the list of the multiple first object types.
9. The workstation shall include a search tool to create a list of objects based on specific criteria

a. Name
b. Object type
c. Specific Text in the Properties of the objects.

H. Graphic Displays

1. The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems and building layouts.
2. These graphics shall present point data from the database including any attributes associated with the point such as engineering units, forced by operator status or alarm status.
3. The operator shall be able to:

    a. Change the value of user adjustable parameters from a graphic.
    b. Manually control points and values from a graphic.
    c. Move from graphic to graphic by selecting a link object on the graphic.
    d. Move from a graphic to a trend chart by selecting a link object on the graphic.
    e. Move from a graphic to a time schedule editor by selecting a link object on the graphic.
    f. Move from a graphic to an alarm view by selecting a link object on the graphic.

4. Graphics should rescale based on whatever monitor or viewing device is being used.
5. Graphic expectations are symbolized with samples at the end of the specifications.

I. Graphics Editor

1. The engineer shall be able to import gif, png, bmp, jpeg, tif and CAD generated picture files as background displays, and layering shall be possible.
2. Java Script for customizing the behavior of each graphic shall be supported.
3. Scalable Vector Graphics (SVG) technology shall be supported.
4. A library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges and graphs that can be dropped onto a graphic being created shall be included with the editor. These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.
5. Changing screen locations, size, color, text, blinking or changing from one graphic to another graphic shall be possible based on status changes or alarm conditions in the data linked to the graphic.
6. It shall be possible to associate a specific graphic to a specific database object and launch the graphic based on specified changes in the database object.
7. Moving from one graphic to another graphic shall not require the operator to use the system database tree.
8. It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable libraries.
9. It shall be possible to create graphics on varying layers that can be moved and reused.
10. It shall be possible to create graphics within varying window panes that can be moved and/or re-referenced. For example, creating the graphical menu within a pane and referencing it on every graphics page, so that the pane is a single component allowing for easy changes.

11. Additional graphic editor tools shall include:

    a. Create and save pages
    b. Group and ungroup symbols
    c. Modify and existing symbol

d. Modify and existing graphic page
e. Rotate and mirror a symbol
f. Place a symbol on a page
g. Place analog dynamic data on a page in decimal format
h. Place binary dynamic data on a page using state descriptors
i. Create motion through the use of animated gif files or JavaScript
j. Place “Forced by Operator” mode indication on a page
k. Place links using a fixed symbol or flyover on a page
l. Place links to other graphic pages on a page
m. Place links to web sites on a page
n. Place links to notes on a page
o. Place links to a time schedule on a page
p. Place links to any exe file on the operator work station
q. Place links to Microsoft Word files on a page
r. Assign a background color
s. Assign a foreground color
t. Place alarm indicators on a page
u. Change symbol/text/value color as a function of an analog variable value
v. Change a symbol/text/value color as a function of a binary state
w. Change a symbol/text/value as a function of a binary state

12. All symbols used by Schneider Electric Buildings Business in the creation of graphic pages shall be saved to a library file for use by the owner.

J. Automatic Data Collection

1. The software shall provide for the long term collection and storage of data from the NSCs and Field Bus Controllers.
2. The type of logging and frequency shall be user adjustable.
3. Refer to the requirements defined in the section describing the Network Server Controller.

K. Alarm Management

1. The Enterprise Server database shall include an alarm management system.

   a. The ES alarm management system shall receive all alarm messages generated by alarm objects in the ES database.

2. The Network Server Controller database shall include an alarm management system.

   a. The NSC alarm management system shall receive all alarm messages generated by alarm objects in the NSC and any field bus controllers that are sub-ordinate to the NSC.

3. All alarms, regardless of the database location, shall appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics or reports.

4. The point of connection by the user shall determine what alarms are available to the user.

a. A workstation connection to the ES shall present all alarms to the user.
b. A workstation connection to an NSC shall present the alarms that exist in the NSC alarm management system.

5. The state of an alarm shall be a database variable.

a. States shall include; normal, in alarm unacknowledged, in alarm acknowledged and returned to normal without acknowledgement.
b. This database variable may be used to create new alarms based on alarm management criteria such as “an alarm has gone unacknowledged for more than 5 minutes”. This new alarm can then be routed to a different receiver.

6. Alarm Features:

a. A minimum of 1000 alarm notification levels. Each level shall have a unique set of parameters for controlling alarm display, distribution, acknowledgment, keyboard annunciation and record keeping.
b. Automatic logging in the database of the alarm message, point name, point value, source device, timestamp of the alarm, username and time of acknowledgement.
c. The ability to customize an active alarm viewer for each user shall be provided. What levels to display and what attributes to display shall be fully configurable.
d. An audible sound upon alarm initiation, and return to normal shall be configurable.
e. Routing of alarm messages to specific users and/or specific user groups during specific time periods and on specific days shall be configurable. The same alarm may be routed to different users and/or user groups for alternate time periods or specific days.
f. The font type and color and background color for each alarm notification level shall be configurable.
g. The active alarm viewer shall be configurable such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions and a drop-down list of causes for specific alarms.
h. The active alarm viewer shall be configurable such that an operator must confirm that all of the steps in a check list have been accomplished prior to acknowledging the alarm.
i. An operator shall have the ability to assign an alarm to another user of the system. Such assignments shall be tracked.
j. The system shall have the ability to send an email alarm message or an alphanumeric pager message to specific users or user groups without a customer email client or special software interface running on the server. The system shall also support email with the customer’s email client on the server.

L. Scheduling

1. Primary time schedules shall be located in the Network Server Controllers and stored in their local RAM.

a. Commands from these schedules shall be sent to applications in the NSC and in field bus controllers.
b. Calendars and holidays shall also be located in the NSCs.

2. Master Schedules (Lead Schedules), Calendars and Holidays may exist in the Enterprise Server.

    a. These master events shall be linked to the schedules in the NSCs.

3. Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.
4. Schedules shall be programmable for a minimum of one year in advance.
5. To change a schedule for a particular day, a user shall imply select the day and make the desired changes.
6. Using web access, the user shall be able to view schedules as an entire year, a month, a week or a day. A simple mouse click shall change the view. Scrolling from one month to another month shall be possible.
7. Schedule changes made by an operator shall automatically be transmitted to the schedule object in the NSC.
8. The Master Schedule concept used between the ES and NSCs shall also exist within an NSC. A Master Schedule in an NSC may be associated with multiple standard schedules within the same NSC.
9. It shall be possible to assign one or more lists of exception event days, dates, date ranges to a schedule.
10. It shall be possible to view combined views showing the calendar and all prioritized exceptions on one screen.
11. The exception system shall accommodate a minimum of 16 priority levels.
12. The output of a schedule shall be bound directly to a value without the need of support from an application program.

M. Programmer’s Environment

1. The requirements for application programming software are described under the sections on the Network Server Controller and Programmable Process Controller.
2. It shall be possible to save application programs in the NSC and PPC as libraries for reuse within this project and on other projects.
3. Reusing a library application file shall only require a simple import command.
4. Graphically programming applications in the NSC shall be viewable with live data in real time.
5. Applications in the NSC shall have configurable cycle times to allow for prioritized application execution.
6. It shall be possible to create binding templates allowing the engineer to bind multiple connections to a single object in a single set of keystrokes.
7. It shall be possible to create objects that allow common devices such as power meters, VFD drives, etc. to be integrated into the system with simple drag and drop actions without the need for complicated programming.
8. Within the line programming software took, key terms should appear when typing (IntelliType).

N. Saving/Reloading

1. It shall be possible to copy the entire database from any server or controller and save it in a file that can be restored to the original server or controller or a new server or controller.

2. A software tool(s) shall be provided that allows an engineer to update the firmware for all servers and controllers.
3. In the ES and NSC, it shall be possible to create libraries that consist of a collection of objects within the database for reuse in this project and on other projects. All connections between the objects within the library shall be retained during the library creation process.

O. Audit Trail

1. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.
2. It shall be possible to view a history of alarms, user actions and command for any system object individually or at least the last 5000 records of all events for the entire system.
3. It shall be possible to save custom filtered views of event information.

P. Search Function

1. It shall be possible to configure a search object that will search a defined portion of the database and present a collection of defined objects in a single list view.
2. It shall be possible to save configured search objects for reuse.

2.12 WEB BASED OPERATOR SOFTWARE

A. General:

1. Day to day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any part of the system from anywhere on the network.
2. The system shall be able to be accessed on site via a mobile device environment with, at a minimum, access to overwrite and view system values.
3. It shall not be necessary to install additional client software on the web based operator workstation.

B. Graphic Displays:

1. The browser based interface must share the same graphical displays as available via the standard workstation interface. The same information shall be presented by the graphics.
2. The browser's graphics shall support commands to change set points and enable/disable points.

C. Navigation and Actions:

1. The browser based interface shall allow the operator to navigate throughout the entire system. Changes made to any point, value or schedule shall be effective immediately with a record of the change stored in the event list.

D. Alarm Management:

1. An alarm viewer with the same information that is presented to a standard workstation user shall be available to a web user.
2. Web operators shall be able to silence alarms and acknowledge alarms.
3. The capability to add specific text to the alarm record prior acknowledgement of the alarm shall be possible.
4. Alarm attachments shall be viewable.

E. Groups and Schedules:

1. Web operators shall be able to view pre-defined groups of points with their values updated automatically.
2. Web operators shall be able to change existing time schedules.

a. Change start and stop times
b. Add new start and stop times
c. Modify calendars

F. User Accounts and Audit Trail:

1. The same user accounts used for standard workstation access to the system shall also function for web access. Different passwords shall not be required.
2. All user activity via web access to the system shall be recorded in the event history for the system.

2.13 WEB SERVICES

A. The ES and NSC shall support the use of the following for communication at the WAN/LAN layer of the system architecture using web services:

1. HTTP: Hyper Text Transfer Protocol
2. SOAP: Simple Object Access Protocol
3. XML: eXtensible Markup Language

B. The ES and NSC shall be able to serve and consume data via web services.

C. Customized web services shall be provided for the following:

1. SmartStruxure Data Center Expert
2. SmartStruxure Power Manage Expert

PART 3 - EXECUTION

3.1 CONTRACTOR RESPONSIBILITIES

A. General

1. Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the

Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training and warranty requirements of the project be delegated to a subcontractor.

B. Demolition

1. The Owner will inform the Contractor of any equipment which is to be removed that will remain the property of the Owner. All other equipment which is removed will be disposed of by the Contractor. All components of the existing BMS that are no longer required as part of the new BMS, shall be removed. This includes abandoned wiring, conduit and pneumatic tubing as a minimum.

C. Access to Site

1. Unless notified otherwise, entrance to buildings is restricted. No one will be permitted to enter any building unless their names have been cleared with the Owner or the Owner's Representative.

D. Examination

1. The Contractor shall verify that systems are ready to receive work.
2. The beginning of installation implies that the Contractor accepts the existing conditions.
3. The Contractor shall thoroughly examine the project plans for control device and equipment locations. Discrepancies, conflicts or omissions shall be reported to the Engineer before rough-in work is started.
4. The Contractor shall inspect the site to verify that equipment is installable as designed. Any discrepancies, conflicts or omissions shall be reported to the Engineer before rough-in work is started.
5. The Contractor shall examine the drawings and specifications for work by others. If head room or space conditions appear inadequate or if any discrepancies occur between the plans for work under this contract and the plans for work by others, the discrepancies shall be reported to the Engineer and the contractor shall obtain written instructions from the Owner for any changes necessary to accommodate the work under this contract with the work of others.

E. Protection:

1. The Contractor shall protect against and be liable for damage to work and to material caused by the Contractor's work or employees.
2. The Contractor shall be responsible for work and equipment until inspected, tested and accepted.
3. The Contractor shall be responsible for protecting materials awaiting installation.
4. The Contractor shall cover open ends systems and system components with temporary covers, plugs or other methods of closure during storage and construction to prevent entry of foreign objects.

F. Continuity of Existing System Operation:

1. When it is necessary to take an existing system offline on a piece of equipment that is servicing occupied areas – before commencing any work – all work must be coordinated

with other pertinent contractors and the owner's representative for an agreeable temporary solution. IE: AHU may use a temporary t-stat in the return duct to control a chilled water valve where the unit is placed in "Hand" with the fan running 24 hrs.

G. Site Meetings:

1. The Project Manager for the Contractor shall attend a weekly site coordination meeting that will be attended by all of the contractors involved in this project. The Contractor shall allocate a minimum of 3 hours for this meeting. At the first meeting of each month, the status report submittals shall be delivered to the Owner.

H. General Workmanship:

1. The Contractor shall install all wiring in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations.
2. Where discrepancies are found between wiring specifications in Division 23 and Division 26, wiring requirements of Division 23 shall prevail for work specified in Division 23.
3. The Contractor shall install equipment, piping, and wiring/raceways parallel to building lines (i.e. horizontal, vertical and parallel to walls) wherever possible.
4. The Contractor shall provide sufficient slack and flexible connections to allow for vibration of piping and equipment such that the vibration shall not cause electrical connections to break.
5. The Contractor shall verify the integrity of all wiring to ensure continuity and freedom from shorts and grounds.
6. All equipment, installation and wiring shall comply with acceptable industry specifications and standards for performance, reliability and compatibility and be executed in strict adherence to local codes and standard practices.

I. Field Quality Control:

1. The Contractor shall continually monitor the field installation for code compliance and quality of workmanship.
2. The Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

J. Coordination With Other Contractors:

1. The Contractor shall assist in coordinating space conditions to accommodate the work under this contract and work by others.
2. Where options exist, the Contractor shall choose execution methodologies that minimize interference with the execution of work by others.
3. The Contractor shall coordinate work schedules with the other contractors that work in the same area to facilitate mutual progress.

K. Coordination With Test and Balance Contractor:

1. The Contractor shall coordinate work progress with the Test and Balance Contractor such that systems and controls are operational when the Test and Balance Contractor arrives to perform the test and balance tasks. If the Test and Balance Contractor schedules his work

without regard to the work progress information provided, and cannot complete the tasks, no liability shall accrue to the Contractor.

2. If the Test and Balance Contractor requires technician support for the test and balance tasks, the availability of the technician shall be coordinated with the Test and Balance Contractor. The Contractor shall not impede the completion of test and balance tasks once systems are ready for test and balance.
3. If the Test and Balance Contractor requires training on the BMS system in order to execute the test and balance tasks, the Contractor shall schedule and deliver this training at an appropriate time relative to the test and balance schedule of work.

L. Coordination With Commissioning Contractor:

1. The Contractor shall coordinate work progress with the Commissioning Contractor such that systems and controls are ready for commissioning when the Commissioning Contractor arrives to perform the test and balance tasks. If the Commissioning Contractor schedules his work without regard to the work progress information provided, and cannot complete tasks, no liability shall accrue to the Contractor.
2. When a system is ready for commissioning, the Contractor shall provide the technician support described in this document in a timely manner.
3. If the Commission Contractor requires training on the BMS system in order to execute the commissioning tasks, the Contractor shall schedule and deliver this training at an appropriate time relative to the commissioning schedule of work.

M. Coordination With the Owner for Operator Training

1. The Contractor shall advise the Owner when the system is sufficiently complete for the operator training to be scheduled.
2. The Owner shall then provide a minimum of two weeks' notice that the owner's personnel are available for the training.

3.2 INSTALLATION REQUIREMENTS

A. Existing Equipment

1. Interconnecting control wiring that becomes obsolete as a result of new work shall be removed by the Contractor and become the property of the Contractor unless specifically advised otherwise by the owner.
2. Pneumatic tubing that becomes obsolete as a result of new work shall be removed by the Contractor and become the property of the Contractor unless specifically advised otherwise by the owner.
3. Control panels that become obsolete as a result of new work shall be removed by the contractor and delivered to the Owner.
4. Unless otherwise specified on the contract drawings, the Contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers or actuators. Should the Contractor find existing equipment that does not operate properly or is need of maintenance or repair, the Contractor shall notify the Owner.
5. Unless otherwise specified on the contract drawings, the Contractor may reuse existing temperature sensor wells in piping for temperature sensors. The Contractor shall modify the existing wells as necessary for proper fit of the new sensors.

6. Where existing items are no longer required, the Contractor shall remove the items and deliver them to the Owner unless notified otherwise, in which case they will become the property of the Contractor.

   a. Thermostats
   b. Controllers
   c. Auxiliary Electronic Devices
   d. Pneumatic Controllers
   e. Damper Actuators, Linkages and Appurtenances
   f. Control Valves

7. When the Contractor acquires removed equipment items and chooses to dispose of them, the disposal process must meet all the local requirements for general disposal and hazardous materials disposal.

B. Wiring, Conduit, Cable Characteristics and Installation Details

1. All wire shall be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Standard	600 Volt
Class Two	18 Gauge Standard	300 Volt
Class Three	18 Gauge Standard	300 Volt
Communications	Per the Manufacturer	Per the Manufacturer

2. Power and Class One wiring may be run in the same conduit.
3. Class Two and Class Three wiring and communications wiring may be run in the same conduit.
4. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
5. Unless a written exception provided by the FAA Resident Engineer, all system wiring must be in conduit or an acceptable wireway/cabletray wiring support system ALL conduit must be a minimum of 3/4” and shall be installed in the following manner:

   a. Parallel and perpendicular to all building lines.
   b. EMT is acceptable in interior locations not subject to physical damage and above 10’ for surface mount applications.
   c. All conduit shall be BLUE in color to clearly identify control system raceways.
   d. All conduit/flexible conduit and other raceways must be strapped and fastened as per NEC Electrical Code requirements.
   e. Rigid or IMC conduit shall be utilized for all exterior locations and interior locations below 10’.

f. All exterior installations shall utilize stainless steel hardware and J-boxes. As an alternate, an approved weather shield may be provided as part of an assembly by a single manufacture.
g. Control wiring and conduit shall not block or restrict access to any serviceable areas (doors, openings, etc.)

6. Flexible metallic conduit with a maximum length of 3 feet shall be used for connections to motors, actuators, controllers and sensors mounted on vibrations producing equipment. Liquid-tight flexible conduit shall be used in exterior locations and interior locations subject to moisture.
7. Junction boxes shall be provided at all cable splices, equipment termination and transitions from EMT to flexible conduit. Interior J-boxes shall be galvanized pressed steel, nominal four inch square with black cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and covers with gaskets.
8. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings.

   a. Exception: Any wire run in suspended ceilings that must be intact for the fire management system to control building systems, shall be installed in conduit.

9. Low voltage wiring shall meet National Electric Code Class 2 requirements. Sub-fuse low voltage power circuits as required to meet Class 2 current limits.
10. All wiring in mechanical, electrical, or service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 10 feet.
11. Where Class 2 wiring is exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 10 foot intervals.
12. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
13. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire to wire connections shall be at a terminal block.
14. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
15. Maximum allowable voltage for control wiring shall be 77 Volts. If only higher voltages are available, the contractor shall provide step-down transformers.
16. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
17. Install plenum wiring in sleeves where it passes through walls and floors. Maintain the fire rating at all penetrations.
18. The size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and National Electric Code requirements, except as noted elsewhere.
19. Include one pull string in each raceway that is 1 inch in diameter or larger.
20. Use coded conductors throughout with conductors of different colors.
21. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
22. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway, to maintain a minimum clearance of 6 inches from high-temperature equipment such as steam pipes or flues.

23. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
24. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
25. The contractor shall terminate all control and/or interlock wiring and shall maintain updated as-built wiring diagrams with terminations identified at the job site.
26. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with coupling according to code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.
27. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.
28. Only glass fiber is acceptable, no plastic.
29. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BMS contractor shall submit to the Owner the name of the intended contractor of the fiber optic cable with the project submittals.

C. Communication Wiring:

1. The contractor shall adhere to the items listed in the previous section on WIRING.
2. The contractor shall install all cabling in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
3. The contractor shall not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
4. Communication cables shall be protected by a surge arrestor device in the following instances (known acceptable source: SA-1 manufactured by Schneider Electric):

    a. Vertical conduit/wiring.
    b. Underground conduit/wiring.
    c. Above ground conduit/wiring exiting and/or entering the building envelope.

5. The contractor shall install all runs of communication wiring with un-spliced lengths when that length is commercially available.
6. The contractor shall label all communication wiring to indicate origination and destination data.
7. When shielded wiring is use, the contractor shall ground the shield only once for each continuous segment of cable.

    a. The shield shall be grounded at the NSC for the RS485 cable that connects to the NSC.
    b. The shield shall be grounded at the RS485 router when a router is used to add a downstream RS485 LAN.

8. All wiring shall be terminated in an approved junction box, condulet or other approved enclosure.
9. All wiring shall be run continuously from origin to its final termination point.

D. General Installation Practices for Field Devices

1. Well mounted sensors shall include thermal conducting compound within the well to ensure good heat transfer to the sensor.
2. Actuators shall be firmly mounted to give positive movement and linkage shall be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
3. Relay outputs shall include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
4. Water line mounted sensors shall be removable without shutting down the system in which they are installed.

E. Sensors:

1. The contractor shall install sensors in accordance with the manufacturer's recommendations.
2. The location of sensors shall be as indicated on mechanical and architectural drawings.
3. The contractor shall mount sensors rigidly and adequately for the environment within which the sensor operates.
4. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
5. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
6. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
7. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the duct. Each bend shall be supported with a capillary clip. Provide 1 foot of sensing element for each square foot of coil area.
8. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in the thermal wells.
9. Install outdoor air temperature sensors on the north wall, complete with a sun shield at the designated location.

F. Differential air pressure and static pressure sensors:

1. The location of pressure sensors shall be as indicated on the mechanical drawings.
2. For supply duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90 degree angle to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
3. For return duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90 degree angle to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
4. For building static pressure, pipe the low-pressure port of the sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
5. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

6. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels and not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without the use of ladders or special equipment to the maximum extent possible.
7. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.
8. Annular pitot tubes shall be installed so that the total head pressure ports are set-in-line with the pipe axis upstream and the static port facing downstream. The total head pressure ports shall extend diametrically across the entire pipe. Annular pitot tubes shall not be used where the flow is pulsating or where pipe vibration exists.

G. Flow Switches:

1. The location of flow switches shall be as indicated on the mechanical drawings.
2. Airflow Switches

    a. Install in horizontal duct runs whenever possible.
    b. If a vertical duct run is the only option, then install in a location with an upward airflow.

3. Hydronic Switches

    a. Use the correct paddle type for the pipe diameter as described by the switch manufacturer.
    b. Adjust the flow switch in accordance with the manufacturer’s instructions.

H. Actuators:

1. Damper actuators shall be provided with all mounting hardware and linkages.
2. Mount and link control damper actuators according to manufacturer’s instructions.
3. When spring return actuators are used on normally closed dampers, the seals shall be compressed when the dampers have been closed by the actuator.
4. Damper/actuator combinations shall modulate smoothly from fully closed to fully open and return.
5. Electric/Electronic Damper Actuators shall be direct-mounted on the damper shaft or jackshaft unless shown as a linkage installation. They shall be mounted following the actuator manufacturer’s recommendations.
6. Electric/Electronic Valve Actuators shall be connected to the valve with adapters approved by the actuator manufacturer. They shall be mounted following the actuator manufacturer’s recommendations.

I. Controllers:

1. Install programmable process controllers, supervisory logic controllers and application specific devices on each field bus to meet the requirements of the sequence of control for all systems.

    a. SLCs shall only be used when the NSC is unable to support supervisory logic in support of field bus controllers.

2. All process control loops for an integral system shall reside in a single controller. Each controllable end device creates one process control loop. Examples of integral systems are:

   a. Air handling units
   b. Packaged chillers
   c. Chillers, excluding pumps and tower
   d. Boilers

3. To the maximum extent possible, all process control loops for built up systems shall reside in a single controller. An example is a chiller with its associated chilled water pumping systems or a boiler system with its associated heating hot water pumping systems. The objective of this requirement is that the contractor shall use large point count, primary controllers in lieu of multiple secondary controllers.
4. To the maximum extent possible supervisory logic for integral and built up systems shall reside in the NSC.

J. Control Dampers:

1. Install dampers in accordance with the manufacturer's instructions to operate and to obtain leakage rates specified herein. Adjust the damper linkage such that the damper closes before the actuator is fully closed to assure tight shutoff of the damper.
2. Blank-off and seal around dampers and between dampers and sleeves or frames to eliminate air bypass.
3. For outdoor air damper assemblies, stage the opening of each section to prevent stratification and poor mixing of outside and return air.

K. Control Valves:

1. Install in an accessible location, with room for actuator removal and service. Adjust the actuator to provide tight shutoff. Provide valve stem indicator and adjust to indicate proper travel.
2. Where butterfly valves are used, permanently mark the end of the valve shaft to indicate the valve position.

L. Warning Labels:

1. The contractor shall affix permanent warning labels to all equipment that can be automatically started by the DDC system.

   a. Labels shall use white lettering, 12 point type or larger, on a red background.
   b. The labels shall read: "CAUTION: This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to the OFF position before servicing."

2. The contractor shall affix permanent warning labels to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

   a. Labels shall use white lettering, 12 point type or larger, on a red background.

3. The labels shall read: "CAUTION: This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing."

M. Identification of Hardware and Wiring

1. The contractor shall label all wiring and cable, including that within factory-fabricated panels, at each end and within 2 inches of the end of the cable with the DDC address or termination number.
2. The contractor shall label or code each point of field terminal strips to show the instrument or item served.
3. The contractor shall label all control panels with minimum ½ inch letters on laminated plastic nameplates.
4. The contractor shall identify all other control components with permanent labels. All plug-in components shall be labeled on both the removable component and the permanently installed base such that it is obvious where the removed component is to be re-installed.
5. The contractor shall label room sensors relating to terminal box or valves with nameplates.
6. Manufacturer's nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
7. All identifiers shall match the as-built documents.

N. Network Server Controllers

1. Connect NSCs to the owner's TCP/IP network. Locations are identified on the drawings.

2. The NSCs shall be configured and commissioned to ensure that the only data traffic on the TCP/IP is data that is essential for operation of the system. Messages between field devices on the same field bus shall not be allowed to pass onto the TCP/IP network.
3. The NSCs shall be configured to also serve as Web Servers to Web Based Operator Stations.
4. The NSCs shall be linked to the ES database.

O. Enterprise Server

1. The Contractor shall install the Enterprise Server in the location defined on the contract drawings or in a location specified by the Owner.
2. The ES shall be configured to also serve as a Web Server to Web Based Operator Stations.

P. Engineering/Operator Workstation

1. The Contractor shall install the Engineering/Operator Workstation in the location defined on the contract drawings or in a location specified by the Owner.
2. The IP address shall be as assigned by the Owner's IT Department.

Q. The Contractor shall install, license, initialize, start-up and debug all software required for a complete and operational system. This includes any operating system software or other third party software necessary for the successful operation of the system.

R. The Contractor shall provide a complete database and all controller applications to meet the sequence of control and operator interaction requirements.

3.3 DISTRIBUTED CONTROL REQUIREMENTS

A. The programmed applications for a single integrated system shall not be distributed over more than one field bus.

B. Example 1: A chiller is controlled by a controller on field bus number 1. The controllers that control the pumps and tower shall also be on field bus number 1 as these systems are integrated in their control requirements.

C. Example 2: Multiple air handling units are controlled by controllers on field bus number 1 under NSC number 1. The chiller system is controlled by NSC number 2. The chiller control logic requires the chilled water valve positions from each of the air handling unit controllers. It is acceptable that these related but non-integral systems are controlled by controllers on different field busses or by a second NSC.

3.4 PROGRAMMING FOR NSCS, PROGRAMMABLE PROCESS CONTROLLERS AND SUPERVISORY LOGIC CONTROLLERS

A. The contractor shall create and download application programs that meet the requirements of the sequence of control, time scheduling requirements, trend logging requirements and alarm handling requirements.

B. The contractor shall use a consistent point naming concept throughout the project that allows for easy transition from building to building and system to system.

C. All time schedules shall be fully configured with weekly schedules and all of the holidays identified by the owner.

D. All trend logs identified in the sequence of control shall be fully configured and operational.

E. All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.

F. All user adjustable parameters identified as (adj) in the sequence of control shall be viewable and writable and appropriate initial values shall be set.

G. All external point values and internal point values identified as (rpt) in the sequence of control shall be viewable.

H. Manual control (force by operator) of all external points shall be possible from list views and graphics. The forced by operator status of a point shall be readily visible to the system operator from both the list views and graphics.

I. For all variables broadcast onto the field bus, event driven communication shall be used to avoid data storms. As a minimum the program shall provide for the use of at least two of the following three parameters for each output network variable:

1. Send on delta parameter
2. Minimum send time parameter for each output variable.
3. Maximum send time (guaranteed transfer time)

J. The contractor shall embed into the programs sufficient comment statements to clearly describe each section of the program. This applies to both line programming and graphical programming system.

K. With graphical programming systems with multiple layers for the function block diagrams are used, no more than two layers shall be used.

3.5 CONFIGURATION OF APPLICATION SPECIFIC CONTROLLERS

A. Application Specific Controllers shall be fully configured to meet the sequence of control and physical characteristics of the equipment being controlled.

1. Physical device selection parameters (series fan or parallel fan, etc.)
2. Thermodynamic parameters (cooling set point, heating set point, etc.)
3. Timing parameters (sample rates, integral time constants, etc.)
4. Communication parameters (send heartbeat, minimum send time, etc.)

B. For each ASD, documentation of all parameter settings shall be included in the as-built submittals.

3.6 DEVICE TO DEVICE DATA FLOW ON THE FT-10A FIELD BUS

A. This includes control data flow between the NSC and Lon field bus controllers.

B. All device-to-device data flow shall be in place and configured to meet the sequence of control for the new systems and to integrate the existing systems.

C. All device-to-device data flow shall be implemented through the use of LonTalk variables with an appropriate SNVT.

D. Appropriate binding services shall be used to ensure that the average bandwidth utilization is less than 30%. The owner reserves the right to conduct network bandwidth testing to ensure this requirement is met.

E. If reducing the number of devices per field bus is required to meet the network bandwidth requirements, all costs of making changes shall be borne by the contractor.

3.7 SYSTEM UNITS FOR LON BASED PPCS, SLCS AND ASDS

A. The contractor shall use SNVTs with the appropriate units for each input network variable, input application parameter and output network variable.

B. The contractor shall use SCPTs with the appropriate structure for each input application parameter that is based on the SCPT concept.

C. The data shall be presented to the operators visually and using the inch-pound system. The conversion of data from a field level device must be automatically converted from SI units to inch-pound units prior to display.

D. For operator initiated values, the operator shall be able to enter values in units from the inch-pound system of units and the system must then automatically convert the value to units from the SI system of units for dispatch to the field level devices.

3.8 GRAPHIC PAGES

A. Graphic Page Requirements

1. The sequence of control defines the buildings and all of the equipment items to be controlled by the BMS. Graphic pages shall be constructed as described below as applicable (If a central plant is not part of this project, the requirements described below for central plant graphics are moot).
2. The contractor shall develop additional graphic pages to be defined by the owner during the construction period as follows:

a. Up to five additional pages per building.
b. Up to twenty additional global pages when a project involves more than one building.

B. Hierarchy

1. The organization of graphic pages shall be from a global level down to a very detailed level through a series of links.
2. Linking shall allow the operator to move down the hierarchy, up the hierarchy and laterally within the hierarchy.

C. Hierarchy Outline

1. Site Plan Page: A visual representation of the site (map). One page or multiple linked pages depending on the size of the site plan.

a. Link to individual building graphic pages.
b. Display outdoor weather conditions.

2. Utility Management Page: A summary of data on the utility consumption for the site.

a. Link up to the site plan.
b. Display

1) Utility consumption data.

a) Demand data.
b) Voltages, currents and power factors.
c) Demand control actions currently in effect.

c. Presenting the utility management data may require more than one graphic page to effectively report the data from multiple meters.

3. Building Graphic Page: Typically a picture of the building. One page per building.

a. Link to floor plans within the building.
b. Link to central plant graphics where the plant serves the entire building.
c. Link to delivery systems if the delivery system serves the entire building
d. Link up to the site plan.

4. Floor Plan Page: This will be a two dimensional plan of a floor area. A minimum of one page per floor per building is required. Where floor plans are large, multiple linked pages are required. For each control zone the value of the controlled parameters shall be displayed. This will typically be lighting status, temperature and relative humidity if relative humidity is a controlled variable.

a. Link up to the Building page.
b. Link up to the Site Plan page.
c. Link to any delivery system that serves the floor plan area (air handling unit is typical).
d. Link to time schedules that affect the systems that serve the area
e. Link to a Terminal Unit Summary page where multiple zones on the floor are served by unitary control devices such a VAVs or fan coil units.
f. Individual control zones shall be identified.
g. The location of terminal equipment serving each zone shall be shown.
h. The location of sensors installed in the occupied space shall be shown.
i. Where room numbers are available, they shall be shown.

5. Central Plant Page: A graphical representation of the equipment that makes up the plant such as chillers, pumps, boilers, towers etc. If the plant is small, this graphic will display the values of process variables and commands to end devices. If the plant is complex this graphic will just contain links to equipment graphics. A page for each plant is required.

a. Link up to the Building page.
b. Link up to the Site Plan page.
c. Link to Central Plant Equipment Component page (chiller, pumps, tower, etc.).
d. The graphic representation of the equipment shall be 3-dimensional.
e. Display:

1) Process variables.
2) Commands to end devices.
3) Status of end devices.
4) Alarm points if this is the only central plant graphic.
5) Plant status (enabled/disabled).
6) Demand control status.

f. Link to any time schedules that affect the operation of the plant.
g. Link to any pre-configured trend charts associated with the performance of the plant.
h. Link to a Central Plant Configuration Page.

6. Central Plant Equipment Component Page: A graphical representation of an element of equipment such as a chiller, pumps, boiler or tower or some combination of all of these. A page for each primary equipment item per plant is required.

   a. Link up to the Central Plant page.
   b. Link up to the Building page.
   c. Link up to the Site Plan page.
   d. The graphic representation of the equipment shall be 3-dimensional.
   e. Display:

      1) Process variables.
      2) Commands to end devices.
      3) Status of end devices.
      4) Alarm points.
      5) Equipment status (enabled/disabled).
      6) Demand control status.

   f. Link to any time schedules that affect the operation of the equipment component.
   g. Link to any pre-configured trend charts associated with the performance of the equipment component.
   h. Link to a Central Plant Configuration Page.

7. Central Plant Configuration Page: On this page the operator is given access to the configuration parameters for the entire plant or a piece of equipment in the plant. Typically, this page presents data in a tabular format. The type of data on this page is not changed frequently, but the operator may wish to view it frequently. One page per plant for small plants and one page per primary equipment item per plant for larger plants are required.

   a. Set Points.
   b. Tuning Parameters.
   c. Calibration Parameters.
   d. Timing Parameters.
   e. Application parameters.
   f. Reset Schedules.
   g. Lead Lag Information.
   h. Time Schedules.
   i. Link up to the Equipment or Central Plant page.
   j. Link up to the Building page.

8. Delivery System Page: A graphical representation of an air or water delivery system such as an air handling unit, roof top air handling unit, computer room air conditioning unit. One page for each delivery system.

   a. If the Delivery System serves a specific floor area, link up to the Floor Area page.
   b. Link up to the Building page.
   c. Link up to the Site Plan page.
   d. Link to the Central Plant page if the Delivery System is served by a Central Plant.
   e. If the Delivery System supplies multiple terminal devices, link to a Terminal Unit Summary page.

f. Link to a Delivery System Configuration page.
g. The graphical representation of the equipment shall be 3-dimensional and represent the true physical characteristics of the installed system.
h. Display:

1) Process variables.
2) Commands to end devices.
3) Status of end devices.
4) Status of different modes (economizer on/off, mechanical cooling enabled/disabled, occupied/unoccupied).
5) Alarm points.

i. Link to any time schedules that affect the system operation.
j. Link to any pre-configured trend charts for the system.

9. Delivery System Configuration Page: On this page the operator is given access to the configuration parameters for the delivery system. Typically, this page presents data in a tabular format. The type of data on this page is not changed frequently, but the operator may wish to view it frequently. One page per delivery system is required.

a. Display:

1) Set Points.
2) Tuning Parameters.
3) Calibration Parameters.
4) Timing Parameters.
5) Application parameters.
6) Reset Schedules.
7) Lead Lag Information
8) Time Schedules.

b. Link up to the Delivery System page.
c. Link up to the Building page.
d. Link up to the Site Plan page.

10. Terminal Equipment Summary Page: On this page the dynamic data and set points that are associated with multiple terminal units are presented in a tabular format. The objective is to present a summary of terminal unit performance for an area of the facility. One page is required for each group of terminal units. In the tabular data, do not use less than 12 pt font size. Multiple linked pages may be used if there are a large number of terminals served by one delivery system.

a. Display in the table:

1) Process variables.
2) Set points for each process.
3) Command to each end device.
4) Status of each end device.
5) Load factors such as terminal load for a VAV terminal unit.

b. Link to the page for each Terminal Unit.
c. Link up to the Delivery System page.
d. Link up to the Floor Plan page.
e. Link up to the Building page.
f. Link up to the Site Plan page.

11. Terminal Unit Page: A graphical representation of a terminal unit such as a VAV terminal or fan coil terminal. One page for each terminal unit.

a. Link up to the Terminal Summary page.
b. Link up to the Floor Plan page.
c. Link up to the Building page.
d. Link up to the Site Plan page.
e. The graphic representation of the equipment shall be 3-dimensional and shall represent the actual installed terminal unit (if the VAV does not have a fan, a fan should not be shown, etc.).
f. Display

1) Process variables.
2) Command to end devices.
3) Status of end devices.
4) Set points for each process.
5) Modes (auto, heat, cool, etc.).
6) Capacity indicators (terminal load, %heat, %cool, etc.).
7) Reset schedules.
8) Occupancy commands and status.
9) Alarm points.

D. For all points on a graphic page that are subject to being under manual or test mode, the display shall indicate when test mode or manual mode has been applied to the point.

3.9 DEFAULT GRAPHIC PAGES

A. It shall be possible to assign a specific graphic page as a “Default System Graphic” for each User Group and/or each User setup within the system.

B. When a User signs onto the system, the “Default System Page” shall be displayed. Using links, the User may then move from page to page within the system.

3.10 AUTOMATIC TIME OUT

A. When a workstation detects no activity for a specific period of time, the system shall automatically logout the connected user.

B. The same User or a different User shall then be required to enter their User Name and Password to re-enter the system.

3.11 TREND DATA PRESENTATION

A. Trend data shall be presentable in a trend log list with the time stamp and value presented in two columns of data.

1. It shall be possible to copy the data from a trend log list to Microsoft Excel.

B. Trend data shall be presented in trend charts where one or more variables are displayed graphically with the value on the “Y” axis and time on the “X” axis.

1. Each trend chart shall support up to two sets of engineering units for the “Y” axis, one on the left axis and one on the right axis.
2. A single chart may be used to display multiple trend logs as long as the trend logs use one of the two possible engineering unit scales.
3. All trend logs shall be included in a trend chart. The operator shall not be required to create a chart to view the data.
4. The creation process for trend charts shall be native to the system and not require a third party software package.
5. At the operator’s discretion, polling based trend data shall be presented in a trend chart format.

3.12 DYNAMIC APPLICATION FLOW CHARTS

A. Graphically programmed applications in the NSC shall have a graphical viewer that allows the application to be presented in real time with current values displayed on the graphical program with periodic updates. This graphical viewer shall present itself via workstation.

B. Graphically programmed applications in programmable process controllers and supervisory logic controllers shall allow the application to be presented in real time with current values displayed on the graphical program with periodic updates. This viewer shall present itself to a directly connected service laptop running the application programming tool.

3.13 USER GROUPS

A. The contractor shall configure four users groups, one for each level of security. The group names shall be representative of the “names” below:

1. Administrators
2. Engineers
3. Operators
4. Viewers

B. Users

1. The contractor shall configure two users in each user group. The names and passwords shall be representative of the “names” below:

a. Administrators Group

1) Admin1 / Admin1
2) Admin2 / Admin2

b. Engineers Group

1) Engr1 / Engr1
2) Engr2 / Engr2

c. Operators Group

1) Oper1 / Oper1
2) Oper2 / Oper2

d. Viewers Group

1) View1 / View1
2) View2 / View2

2. Administrators shall have full authority over the entire system.
3. Engineers shall have the ability to create, edit, control and view but they shall not be able to add users or set passwords.
4. Operators shall have the ability to control and view only.
5. Viewers shall have the ability to view only.

C. With the exception of the Viewers Group, these users shall not be added to the system until all testing has been completed and the system has been accepted. The contractor shall accept all responsibility for actions that result from the unauthorized issuance of user names and passwords above the level of viewers prior to system acceptance unless specifically instructed to do so in writing by the owner.

3.14 ALARM PROCESSING

A. All alarms required by the sequence of control shall be fully configured for delivery to the operator workstations and the alarm files.

B. A common alarm viewer shall be established to receive alarms from all of the field devices.

C. A separate alarm viewer shall be established on a per building basis to receive just the alarms from that building.

D. It shall be possible to setup unique alarm viewers based on the alarm category (a number from 1 to 1000 assigned to each alarm).

E. The alarm messages shall be descriptive and include as a minimum:

1. System identification
2. Date
3. Time
4. Nature of the alarm such as high value, low value, or fail to start.

F. The system shall be configured to send an alarm message on return to normal.

G. Upon system turnover, all users shall receive all alarms but the system shall have the ability to expose alarm messages to specific users or user groups as desired by the system manager.

3.15 START-UP TESTING

A. The contractor shall furnish all labor and test apparatus required to execute the startup testing plan. Key tasks to be executed and documented in the start-up testing report include:

1. Verification of all primary and secondary voltages.
2. Verification that power wiring for all devices conforms to manufacturer's instructions.
3. Verification that all labeling is in place.
4. Inspection of wiring for loose strands and tight connections.
5. Verification of field bus topology, grounding of shields (if used) and installation of termination devices.
6. Verification that all devices are installed per the submittal.
7. Verification that each I/O device is landed per the submittals and functions per the sequence of control.

   a. Analog sensors shall be properly scaled and a value reported to the OWS.
   b. Binary sensors shall have the specified normal position and the correct state is reported to the OWS.
   c. Analog outputs have the specified normal position and move full stroke when so commanded.
   d. Binary outputs have the specified normal state and respond to energize/de-energize commands.

8. The start-up testing report shall identify the date each task was completed and include the initials of the technician performing the task.

B. The Contractor shall keep the Owner informed of the start-up testing schedule. At least one week's notice must be provided so that the Owner or Owner's representation may observe the execution of the start-up tasks.

C. The Owner shall keep the Contractor informed of any plan to observe the start-up tasks via the weekly management meeting or by email.

3.16 CALIBRATION

A. The Contractor shall ensure that all analog sensors have been calibrated with high quality instrumentation suitable for the sensor being calibrated.

1. The instruments shall display a current (12 month) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of a request.
2. The measured value, reported value, and the calculated offset that was entered into the database shall be recorded.
3. The calibration criteria shall be:

   a. Space Temperature:+/- 0.5 degrees F

b. Air Temperature:+/- 0.5 degrees F
c. Fluid Temperature:+/- 0.5 degrees F
d. Air Flow Rate: +/- 5 %
e. Liquid Flow Rate:+/- 5 %
f. Differential Pressure:+/- 3 %
g. Gauge Pressure:+/- 5%
h. Relative Humidity:+/- 3 % relative humidity
i. CO2: +/- 2 %

B. The Contractor shall document all calibration tasks:

1. Name and location of the sensor
2. Measured value
3. Reported value
4. Date of calibration
5. Initials of the technician performing the task
6. The Calibration Report shall include all of the above.

C. The Contractor shall keep the Owner informed of the calibration schedule. At least one week's notice must be provided so that the Owner or Owner's representation may observe the execution of the calibration tasks.

D. The Owner shall keep the Contractor informed of any plan to observe the calibration tasks via the weekly management meeting or by email.

3.17 LOOP TUNING

A. The contractor shall tune all P, PI and PID control loops under typical operating conditions. Example: A chilled water control loop typically operates between 50 and 65 degrees F. The loop shall be tuned when the chilled water is within this typical operating range. This may require off-season tuning.

B. The PID control applications shall provide for stable changes to loop set points (how often and by how much), so that derivative control is not required unless absolutely necessary.

C. The loop tuning criteria shall be a stable control loop where the average error over 15 minutes and 30 samples shall be less than:

1. Space Temperature:+/- 0.75 degrees F
2. Air Temperature:+/- 1.50 degrees F
3. Air Humidity: +/- 5 % relative humidity
4. Chilled Water Temp:+/- 1.00 degrees F
5. Hot Water Temp:+/- 1.00 degrees F
6. Duct Pressure:+/- 0.2 inches w.g.

D. The Contractor shall document all loop tuning tasks.

1. Name and location of the control loop
2. Results of the tuning

a. Gain in percent per unit of measure
b. Integral time constant in seconds or Integral Gain in percent per unit of measure per second

E. The Contractor shall keep the Owner informed of the tuning schedule. At least one week's notice must be provided so that the Owner or Owner's representation may observe the execution of the tuning tasks.

F. The Owner shall keep the Contractor informed of any plan to observe the calibration tasks via the weekly management meeting or by email.

G. The Owner shall keep the Contractor informed of any plan to observe the tuning tasks via the weekly management meeting or by email.

3.18 PERFORMANCE VERIFICATION TESTING

A. The Contractor shall verify that the performance of the system conforms to the sequence of control.

1. The Contractor shall execute a series of cause and effect tests to ensure that each aspect of the sequence of control is fully implemented.

B. The Contractor shall document:

1. A definition of each functional test
2. The date the test was conducted
3. The initials of the technician performing the test

C. The Contractor shall keep the Owner informed of the tuning schedule. At least one week's notice must be provided so that the Owner or Owner's representation may observe the execution of the functional testing.

D. The Owner shall keep the Contractor informed of any plan to observe the performance verification via the weekly management meeting or by email.

E. This work shall be coordinated with the commissioning agent if applicable.

3.19 OPERATOR INTERACTION TESTING

A. The Contractor shall verify that the performance of the system conforms to the drawings and specification for both an operator workstation and a web based operator interface.

1. Graphics navigation
2. Trend data collection and presentation
3. Alarm handling, acknowledgement and routing
4. Time schedule editing
5. User adjustable parameter adjustments
6. Manual control of points and values
7. System backup process

B. The Contractor shall document:

1. A brief description of each task
2. The date the test was conducted
3. The initials of the technician performing the test

C. The Contractor shall keep the Owner informed of the operator interaction testing schedule. At least one week’s notice must be provided so that the Owner or Owner’s representation may observe the execution of the testing.

D. The Owner shall keep the Contractor informed of any plan to observe the operator interaction testing via the weekly management meeting or by email.

3.20 PERSONNEL AND EQUIPMENT FOR TESTING

A. The Contractor shall provide all labor and equipment required to perform:

1. Start-Up Testing
2. Functional Testing
3. Calibration
4. Tuning
5. Operator Interaction Testing

B. The Contractor personnel conducting the testing shall be competent with and knowledgeable of all project specific systems, hardware and software.

3.21 FAILURES AND RE-TESTING

A. The Contractor shall ensure that all tests achieve satisfactory results.

B. Failures of any test shall result in corrective action and re-testing by the Contractor.

3.22 ON-SITE TRAINING

A. The Contractor shall provide six weeks’ notice of the scheduled time for the delivery of the on-site training defined in Part 1 of this specification.

B. The training shall be conducted by an individual that is familiar with the installed system.

C. The extent of the training and the methodology of delivery shall conform to the information submitted in advance.

D. The training program is a formal event with hands on activities by the students. It is not a “Watch Me” event. Competency is the objective.

E. END OF SCTION 23 09 23

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SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" ASCE/SEI 7. And SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Refer to Section 23 05 48, "Vibration and Seismic Controls for HVAC Piping and Equipment" for force calculation requirements.

1. Seismic Hazard Level AA: Seismic force to weight ratio, 1.00.
2. Seismic Hazard Level A: Seismic force to weight ratio, 0.67.
3. Seismic Hazard Level B: Seismic force to weight ratio, 0.42.
4. Seismic Hazard Level C: Seismic force to weight ratio, 0.21.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.3 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified Licensed Professional Engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

E. Welding certificates.

F. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Lindab Inc.
   b. McGill AirFlow LLC.
   c. SEMCO Incorporated.
   d. Sheet Metal Connectors, Inc.
   e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

   a. Johns Manville.
   b. Maximum Thermal Conductivity:

      1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
      2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

   a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.

1. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
2.

a. Bonded Logic, Inc.

3. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested according to ASTM C 518.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosing’s that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

a. Fan discharges.
b. Intervals of lined duct preceding unlined duct.
c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.7 SEISMIC-RESTRAINT DEVICES

A. Refer to Section 23 05 48, “Vibration and Seismic Controls for HVAC Piping and Equipment for additional requirements.

B. Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.

C. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service or the Office of Statewide Health Planning and Development for the State of California.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

D. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

E. Restraint Cables: ASTM A 603, galvanized steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

F. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

G. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems. “and ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service or the Office of Statewide Health Planning and Development for the State of California.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the COTR if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 painting Sections.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by COTR from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by COTR, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.
    a. The contactor shall be responsible to repair all damaged ceiling systems at no cost to the government.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing."

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units and downstream of Terminal Units :

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: B.

2. Ducts Connected to Constant-Volume Air-Handling Units :

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: B.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units :

a. Pressure Class: Positive 3-inch wg.
b. Minimum SMACNA Seal Class: B.

4. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: B.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units Furnaces and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: C.

2. Ducts Connected to Air-Handling Units :

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2-inch wg.
b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.

2. Ducts Connected to Air-Handling Units :

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units.

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: B.

2. Ducts Connected to Air-Handling Units :

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

G. Liner:

1. Supply Air Ducts: Fibrous glass, Type I, Natural fiber, 1-1/2 inches thick.
2. Return Air Ducts: Natural fiber, 1 inch thick.
3. Supply Fan Plenums: Natural fiber, 1-1/2 inches thick.
4. Transfer Ducts: Natural fiber, 1 inch thick.

H. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: 45-degree entry.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 31 13

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SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Manual volume dampers.
   2. Control dampers.
   3. Fire dampers.
   4. Flange connectors.
   5. Turning vanes.
   6. Duct-mounted access doors.
   7. Flexible connectors.
   8. Flexible ducts.
   9. Duct accessory hardware.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

      a. Special fittings.
      b. Manual volume damper installations.
      c. Control damper installations.
      d. Fire-damper, installations, including sleeves; and duct-mounted access doors.
      e. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

D. Source quality-control reports.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

1.4 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. METALAIRE, Inc.

f. Nailor Industries Inc.
g. Pottorff; a division of PCI Industries, Inc.
h. Ruskin Company.
i. Trox USA Inc.
j. Vent Products Company, Inc.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:

a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

a. Molded synthetic.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Low-Leakage, Steel, Manual Volume Dampers:

1. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. METALAIRE, Inc.
f. Nailor Industries Inc.
g. Pottorff; a division of PCI Industries, Inc.
h. Ruskin Company.
i. Trox USA Inc.
j. Vent Products Company, Inc.

2. Low-leakage rating and bearing AMCA's certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.

4. Frames:

    a. Hat shaped.
    b. Galvanized-steel channels, 0.064 inch thick.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized, roll-formed steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Vinyl or Neoprene.
9. Jamb Seals: Cambered stainless steel.
10. Tie Bars and Brackets: Galvanized steel.
11. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

C. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.3 CONTROL DAMPERS

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Duro Dyne Inc.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. Lloyd Industries, Inc.
8. M&I Air Systems Engineering; Division of M&I Heat Transfer Products Ltd.
9. McGill AirFlow LLC.
10. METALAIRE, Inc.
11. Metal Form Manufacturing, Inc.
12. Nailor Industries Inc.
13. NCA Manufacturing, Inc.
14. Ruskin Company.
15. Vent Products Company, Inc.
16. Young Regulator Company.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. Hat shaped.
2. Galvanized-steel channels, 0.064 inch thick.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design.
3. Galvanized steel.
4. 0.064 inch thick.
5. Blade Edging: Closed-cell neoprene edging.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:

1. Molded synthetic.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.4 FIRE DAMPERS

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. NCA Manufacturing, Inc.
9. PHL, Inc.
10. Pottorff; a division of PCI Industries, Inc.
11. Prefco; Perfect Air Control, Inc.
12. Ruskin Company.
13. Vent Products Company, Inc.
14. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: At or equivalent to the fire rating of the partition or barrier of which it is protecting.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.5 FLANGE CONNECTORS

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.6 TURNING VANES

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.7 DUCT-MOUNTED ACCESS DOORS

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.

3. Ductmate Industries, Inc.
4. Flexmaster U.S.A., Inc.
5. Greenheck Fan Corporation.
6. McGill AirFlow LLC.
7. Nailor Industries Inc.
8. Pottorff; a division of PCI Industries, Inc.
9. Ventfabrics, Inc.
10. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches
d. Access Doors Larger than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.8 FLEXIBLE CONNECTORS

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

2.9 FLEXIBLE DUCTS

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2013.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.11 FIRE-SMOKE DAMPERS:

1. Damper shall be of or greater than the fire and smoke rating of the barrier or partition in which it is mounted.
2. See drawing schedule for damper details.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. At outdoor-air intakes and mixed-air plenums.
3. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
4. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
5. At each change in direction and at maximum 50-foot spacing.
6. Upstream from turning vanes.
7. Control devices requiring inspection.
8. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.

5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment unless otherwise noted.

M. Connect terminal units to supply ducts directly without the use of flexible ducts.

N. Connect flexible ducts to metal ducts with draw bands.

O. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 23 33 00

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SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Centrifugal roof ventilators.

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Roof framing and support members relative to duct penetrations.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00 "Roof Accessories."

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Greenheck.

B. Description: Direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Corrosion Protection: Factory-applied protective coating on all metal components of roof curb and fan assembly.

1. Materials: Electrostatically applied, thermos-setting powdered polyester-urethane, oven cured. 3-mil final coating thickness.

D. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
   1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

E. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

F. Accessories:

   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
   3. Bird Screens: Removable, 1/2-inch mesh, galvanized steel or brass wire.
   4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

   1. Configuration: Built-in cant and mounting flange.
   2. Overall Height: 16 inches.
   3. Sound Curb: Curb with sound-absorbing insulation matrix.
   4. Pitch Mounting: Manufacture curb for roof slope.
   5. Metal Liner: Galvanized steel.

H. Wind Resistance:

   1. Fan Assembly: Miami-Dade NOA or Florida Product Approval certified for use in the Florida HVHZ
   2. Roof Curb: Miami-Dade NOA or Florida Product Approval certified for use in the Florida HVHZ.

I. Capacities and Characteristics:

   1. Electrical Characteristics:

      a. Volts: 115
      b. Phase: 1
      c. Hertz: 60

2.2 MOTORS

A. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.

2.3 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Section 07 72 00 "Roof Accessories" for installation of roof curbs.

C. Secure roof curb and fan assembly to building structure in accordance with manufacturer’s instructions for high-wind application.

D. Install units with clearances for service and maintenance.

E. Label units according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
5. Adjust damper linkages for proper damper operation.
6. Verify lubrication for bearings and other moving parts.
7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
8. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
9. Shut unit down and reconnect automatic temperature-control operators.
10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Refer to Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

C. Lubricate bearings.

END OF SECTION 23 34 23

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SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Shutoff, single-duct air terminal units.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7 SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems". Refer to Section 23 05 48, "Vibration and Seismic Controls for HVAC Piping and Equipment" for force calculation requirements.

   1. Seismic Hazard Level AA: Seismic force to weight ratio, 1.00.
   2. Seismic Hazard Level A: Seismic force to weight ratio, 0.67.
   3. Seismic Hazard Level B: Seismic force to weight ratio, 0.42.
   4. Seismic Hazard Level C: Seismic force to weight ratio, 0.21.

1.3 SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

   1. Air terminal units.
   2. Liners and adhesives.
   3. Sealants and gaskets.
   4. Seismic-restraint devices.

B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
   3. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:

   1. Materials, fabrication, assembly, and spacing of hangers and supports.

2. Design Calculations: Calculations, including analysis data signed and sealed by the qualified Licensed Professional Engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Field quality-control reports.

F. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Known Acceptable Source: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Titus

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel, single wall.

1. Casing Lining: Adhesive attached, 3/4-inch- thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

    a. Cover liner with nonporous foil.
    b. Cover liner with nonporous foil and perforated metal.

2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections, size matching duct size.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

E. Attenuator Section: 0.034-inch steel sheet.

1. Lining: Adhesive attached, 3/4-inch- thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

    a. Cover liner with nonporous foil.
    b. Cover liner with nonporous foil and perforated metal.

2. Lining: Adhesive attached, 3/4-inch- thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

F. Electric Heating Coils: Electric heating coils shall have the following features: automatic reset thermal cutout, secondary manual reset thermal cutout, airflow switch, nickel chrome, heating elements, line terminal block, and control terminal block.

G. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 23 09 23 "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered closed, spring return open, powered open.
2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

   a. Occupied and unoccupied operating mode.
   b. Remote reset of airflow or temperature set points.
   c. Adjusting and monitoring with portable terminal.
   d. Communication with temperature-control system specified in Section 23 09 23 "Instrumentation and Control for HVAC."

3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

H. Control Sequence:

1. Suitable for operation with duct pressures between 0.25- and 3.5-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat.

I. Electrical Disconnect:
1. Provide disconnect per schedules on mechanical drawings.

2.2 HANGERS AND SUPPORTS

A. Refer to Section 23 05 29, "Hangers and Supports for HVAC Piping and Equipment" for additional requirements.

B. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

C. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.3 SEISMIC-RESTRAINT DEVICES

A. Refer to Section 23 05 48, "Vibration and Seismic Controls for HVAC Piping and Equipment" for requirements.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." and ASCE/SEI 7.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the COTR if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.4 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Connect ducts to air terminal units according to Section 23 31 13 "Metal Ducts."

C. Make connections to air terminal units with flexible connectors complying with requirements in Section 23 33 00 "Air Duct Accessories."

3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train FAA's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 00

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SECTION 23 62 00 - PACKAGED COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged, refrigerant compressor and condenser units.

1.3 ACTION SUBMITTALS

A. Product Data: For each compressor and condenser unit. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For compressor and condenser units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

D. ASME Compliance: Fabricate and label compressor and condenser units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 53 "Miscellaneous Cast-In-Place Concrete."

B. Coordinate location of piping and electrical rough-ins.

C. Coordinate electrical components with electrical construction documents and manufacturer’s for the selected and approved unit.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Compressor failure.
b. Condenser coil leak.

2. Warranty Period (Compressor Only): 5 years from date of Substantial Completion.
3. Warranty Period (Components Other Than Compressor): 1 year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 6 TO 120 TONS

A. Known Acceptable Source: Any substitution request needs to be approved by the FAA prior to submitting a bid on the project. Subject to compliance with requirements, provide products by the following or approved equal:

1. YORK; a Johnson Controls company.

B. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.

C. Compressor: Hermetic scroll compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.

1. Capacity Control: Hot-gas bypass.

2. 2-Stage Cooling, Each Circuit.

D. Refrigerant: R-410A.

E. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant. Condenser coil shall be provided with anti-corrosive Modine Electrofin e-coat.

F. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:

1. Permanently lubricated, ball-bearing motors.
2. Separate motor for each fan.
3. Dynamically and statically balanced fan assemblies.
4. Manufacturer’s corrosion protection coating.

G. Operating and safety controls include the following:

1. Manual-reset, high-pressure cutout switches.
2. Automatic-reset, low-pressure cutout switches.
3. Low-oil-pressure cutout switch.
4. Compressor-winding thermostat cutout switch.
5. Three-leg, compressor-overload protection.
6. Control transformer.
7. Magnetic contactors for compressor and condenser fan motors.
8. Timer to prevent excessive compressor cycling.

H. Accessories:

1. Hot-gas bypass kit.
2. Part-winding-start timing relay, circuit breakers, and contactors.
3. Reversing valve.
4. Hot-gas reheat kit.
5. Anti-Corrosive Modine Electrofin e-coat.
6. Concrete Pad installed per manufacture’s recommendations and specification section 03 30 53.
7. Low-Ambient Cooling Kit.
8. Electrical Disconnect per mechanical and electrical drawings.
9. Short-Cycle Prevention.
10. Single-Point Power Connection.
11. Concrete Utility Pad per mechanical details.

I. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:

1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's powder coat. Casing shall meet ASTM B-117.
2. Perimeter base rail (stainless steel) with forklift slots and lifting holes to facilitate rigging.
3. Gasketed control panel door.
4. Disconnect switch to be provided per electrical documents and shall be factory-mounted and wired for single external electrical power connection.
5. Condenser coil hail guard.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.3 SOURCE QUALITY CONTROL

A. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings," Section 6, "Heating, Ventilating, and Air-Conditioning."

B. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install units level and plumb, firmly anchored in locations indicated.

B. Equipment Mounting:

C. Install compressor and condenser units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 53 "Miscellaneous Cast-In-Place Concrete."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

B. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.

C. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Verify proper airflow over coils.

C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Compressor and condenser units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Inspect for physical damage to unit casing.
b. Verify that access doors move freely.

c. Clean units and inspect for construction debris.
d. Verify that all bolts and screws are tight.
e. Adjust vibration isolation and flexible connections.
f. Verify that controls are connected and operational.

B. Lubricate bearings on fan motors.

C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

D. Adjust fan belts to proper alignment and tension.

E. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.

F. Measure and record airflow and air temperature rise over coils.

G. Verify proper operation of condenser capacity control device.

H. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

I. After startup and performance test, lubricate bearings.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain compressor and condenser units.

END OF SECTION 23 62 00

SECTION 23 82 19 - FAN-COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes fan-coil units and accessories.

1.2 DEFINITIONS

A. BAS: Building automation system.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which fan-coil units will be attached.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Perimeter moldings for exposed or partially exposed cabinets.

D. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

G. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.5 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by partition assemblies.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Coil-Unit Filters: Furnish **1** spare filter for each filter installed.
2. Fan Belts: Furnish 1 spare fan belts for each unit installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Known Acceptable Source: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 FAN-COIL UNITS

A. Known Acceptable Source:

1. York

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1/2-inch thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Main and Auxiliary Drain Pans: Non-corrosive or plastic. Fabricate pans and drain connections to comply with ASHRAE 62.1-2004. Drain shall be equipped with condensate overflow switch that shall shut down unit and send an alarm to the DDC system.

E. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by COTR.

1. Vertical Unit Front Panels: Removable, steel, with integral stamped steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

H. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
3. Wiring Termination: Connect motor to chassis wiring with plug connection.

I. Control devices and operational sequences are specified in Section 23 09 23 "Instrumentation and Controls for HVAC."

J. Electrical Connection: Factory wire motors and controls for a single electrical connection.

K. Provide electrical disconnect per mechanical and electrical drawings.

L. Provide all accessories listed on mechanical drawings.

M. Provide coil with anti-corrosive Electrofin e-coat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 60 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

F. Condensate drain shall be routed to existing floor drains.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect and insulate new refrigerant linesets per manufacturers' recommendations.
3. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Section 23 33 00 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26 requirements.

D. Connect wiring according to Division 26 Requirements.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to one visit to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train FAA's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Section 01 78 23, “Operation and Maintenance Data.”

END OF SECTION 23 82 19

SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. General:

1. The general electrical requirements in this section are applicable to both Government Furnished Equipment (GFE) and non-GFE. Materials and equipment shall comply with all requirements of the contract documents. Materials furnished by the Contractor shall be new, the standard products of manufacturers regularly engaged in the production of such materials, and of the manufacturer's latest designs that comply with the specification requirements. If material and equipment requirements conflict, the order of precedence for selection shall be as follows: special contract provision, this specification, the contract drawings; and then in continuing order of precedence, military specifications, federal specifications, NFPA publications, IEEE standards, UL standards and NEMA standards. Wherever standards have been established by Underwriters Laboratories, Inc., the material shall bear the UL label.

1.2 REFERENCES

A. FAA Orders and Standards:

1.	FAA-STD-1217f,	Electrical Work, Interior
2.	FAA-STD-1391B	Installation and Splicing of Underground Cables
3.	FAA-STD-019f,	Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Electronic Equipment

B. National Fire Protection Association (NFPA)

1.	NFPA 70,	National Electrical Code.
2.	NFPA 110	Standard for Emergency and Standby Power Systems
3.	NFPA 780	Standard for the Installation of Lightning Protection Systems

C. Institute of Electrical and Electronic Engineers (IEEE)

1.	IEEE C2	National Electrical Safety Code
2.	IEEE Std 100	Dictionary of Electrical and Electronics Terms

D. National Electrical Manufactures Association (NEMA)

1.	NEMA C57.12.28	Pad-Mounted Equipment - Enclosure Integrity
2.	NEMA ICS 6	Industrial Control and Systems Enclosures
3.	NEMA MG 1	Motors and Generators

4.	NEMA MG 10	Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
5.	NEMA MG 11	Energy Management Guide for Selection and Use of Single-Phase Motors

1.3 ELECTRICAL CHARACTERISTICS

A. Provide the following electrical equipment and systems:

1. Equipment, wiring devices and electrical connections required for installation of electrical equipment.
2. Raceways and wiring for power and controls.
3. Cutting and patching for electrical construction.
4. Excavation and backfill for underground utilities and services.

B. Product Requirements:

1. Provide products which conform to and installation that complies with the requirements of the ABA.

C. Spacing Requirements:

1. Electrical equipment sizes indicated on the drawings are generally based on specified manufacturer. Verify that the equipment proposed will fit in the space indicated on the drawings. Coordinate building dimensions with architectural and structural drawings. Equipment furnished and installed under other Sections of this Specification shall be coordinated with the requirements of this Section. Maintain clearances required by NFPA 70 around electrical equipment. Establish the exact location of electrical equipment based on the actual field verified dimensions of equipment furnished.

D. Departure from Dimensions Shown:

1. Minor departures from exact dimensions shown in electrical plans may be permitted when required to avoid conflict or unnecessary difficulty in placement of a dimensioned item, provided all contract requirements are met. The Contractor shall promptly obtain written approval from the Contracting Officer's Technical Representative prior to undertaking any such departures and shall provide appropriate documentation of the departure.

1.4 SUBMITTALS

A. Product Data: For each type of product specified.

B. Samples: When the adequacy, quality and safety of a material will be better demonstrated and it will expedite approval, provide single samples of items proposed for use. Conform to the procedures specified. Submit samples of color, lettering style, and other graphic representation required for each identification product for the project.

C. Test Reports:

1. Operating Tests:

a. An interim operating and performance test shall be performed for each major equipment item after installation is complete and before the item is placed in service. After systems have been completely installed and balanced, test each system for proper operation. Tests shall be conducted in the presence of the COR under design conditions to ensure proper sequence and operation throughout the range of operation. Make adjustments as required to ensure proper functioning of the systems. Special tests on individual systems are specified under individual sections. Tests shall be scheduled and approved in writing by the Contracting Officer's Technical Representative at least 21 calendar days prior to conducting tests. Contractor shall demonstrate, to the Contracting Officer's Technical Representative's satisfaction, proper operation of control devices by simulating actual operating conditions. Devices tested shall include, but not be limited to, flow and pressure controls, temperature controls, and system interlocks and alarms. Operating tests for GFE will be performed by the GFE vendors at the Government's expense. Contractor shall have a representative on site to witness all GFE tests.

b. Submit a summary of the Electrical Test Report and Motor Test Report, noting deviations from requirements listed below:

1) Maximum plus or minus 5 percent variation between nominal system voltage and no load voltage.
2) Variation between motor average phase current and measured individual phase currents does not exceed the manufacturer's specified limits.
3) Maximum plus or minus 10 percent variation between average phase current and measured individual phase currents for panelboards.

D. Operation and Maintenance Data:

1. Provide three copies of operating and maintenance instructions, equipment service manuals, catalog cuts and illustration as described in this section. The operations and maintenance (O&M) data shall be placed in suitable binders for use by maintenance personnel. The material shall include equipment model and serial numbers, performance characteristics, power and utility requirements and manufacturers recommended maintenance schedules. Final acceptance of this equipment is contingent upon submission of required documents to and approval by the Contracting Officer's Technical Representative prior to the facility turnover.

Operating and maintenance instructions shall contain the following minimum data and shall comply with submittal requirements specified in individual Division 26 Sections.

a. Operating instructions shall include illustrations and explanations for controls, initial set points and startup and shutdown procedures for both normal and emergency conditions.

b. Maintenance instructions shall include periodic inspection and lubrication requirements and where applicable, equipment performance verification requirements.
c. Troubleshooting and fault diagnosis data shall list trouble symptoms, instructions necessary to determine cause of trouble and the action required to restore equipment to operating condition.

2. Repair instructions.
3. Spare parts list.
4. Include a list of required tools and equipment to maintain the system.
5. Provide names, addresses and telephone numbers of all service organizations that supply repair parts for the system or systems to be furnished.
6. Repair Instructions:

   a. Include equipment disassembly, repair, replacement and re-assembly. Checkout or test data shall also be provided. Reprogramming instructions shall be provided for equipment having a programmable memory. Re-packing instructions shall be provided for sending equipment to the manufacturer or to a repair depot for repairs. The instructions shall contain a list of spare parts recommended by the equipment manufacturer to support the operation of the equipment for a 1-year time period.

7. Parts List:

   a. A parts list shall be furnished that includes part names and part numbers that are shown on illustrations or tables. The parts list shall identify the actual manufacturer of the part, replacement cost and shall also contain a notation of identifying products as commercial grade for common non-special design hardware.

8. Overhaul Instructions:

   a. The O&M data shall include overhaul instructions that are required to return the equipment to full operational capability in the event that the machinery stops working properly.

9. O&M Data:

   a. The O&M binder shall include tabs for insertion of all GFE data. Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “Operation and Maintenance Data.” The O&M data shall contain as appropriate, the following:

      1) Wiring diagrams.
      2) Electrical schematics.
      3) Control diagrams.
      4) Wire terminal assignments.
      5) Equipment layouts.

10. Record electrical drawings, modified to record actual conditions and modifications, including dimensions.

11. Approved shop drawings.
12. A list of all subcontractors used on the project with address and phone number.

E. Substitutions: Contractor shall submit in accordance with Section 01 25 00 “SUBSTITUTION PROECDURES”

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70 and FAA-C-1217f for components and installation. In case of conflict between provisions of codes, laws and ordinances, the more stringent requirement shall apply.

B. Material and Equipment Qualifications: Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

C. Listing and Labeling:

1. Provide products specified in the Section that are listed and labeled. The terms "listed and labeled" as defined in the National Electrical Code, Article 100. Listing and labeling agency qualifications: NRTL as defined in 29 CFR 1910.7.

D. Summary:

1. Submit a summary of the Electrical Test Report and Motor Test Report, noting deviations from requirements listed below:

   a. Maximum plus or minus 5 percent variation between nominal system voltage and no load voltage and between no load and full load voltage.
   b. Variation between motor average phase current and measured individual phase currents does not exceed the manufacturer's specified limits.
   c. Maximum plus or minus 20 percent variation between average phase current and measured individual phase currents for panelboards.

E. Equipment Training (Non-GFE):

1. After final tests and adjustments have been completed, fully instruct the Contracting Officer's Technical Representative and other personnel, as directed by the Contracting Officer's Technical Representative in details of operation and maintenance of special equipment, including control system as installed. Submit outline of proposed instruction course 21 days prior to start for approval by the Contracting Officer's Technical Representative.

F. Project Record Documents

1. Maintain at the job site a separate set of white prints of the contract documents for the purpose of recording the system and dimension changes of those portions of work in which actual construction is at variance with the contract documents. The Contractor shall record changes for both GFE and Contractor provided equipment. Upon acceptance of the project, submit documents to the Contracting Officer's Technical Representative, with verification of data accuracy. Mark the drawings with colored pencil. Prepare the drawings as the work progresses. Upon completion of work submit drawings clearly indicating the following:

   a. Locations of devices, conduits, equipment and other pertinent items. Indicate the depth of buried ducts and direct burial cable.

   b. Schematic and interconnection wiring diagrams of the completed power and control system incorporating the data derived from the equipment shop drawings and the cable and conduit schedule. The drawings shall be detailed to wire and terminal block numbers, conductor color coding, device designations locations and reflect identifications established at the site.

   c. Cable and conduit schedule for cables and conduits actually installed; include the type, size, origin, destination, and approximate length for each cable and conduit. Indicate for each cable the voltage rating, number of conductors, cable number, color coding and routing.

G. Material and Equipment Manufacturing Date: Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 POSTED OPERATING INSTRUCTIONS

A. Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

1. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
2. Start up, proper adjustment, operating, lubrication, and shutdown procedures.
3. Safety precautions.
4. The procedure in the event of equipment failure.
5. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

B. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.7 DELIVERY, STORAGE AND HANDLING

A. Contractor provided equipment shall be protected from damage and stored in a dry location from the time of site delivery. Furnish and energize space heaters or provide desiccant recommended by the equipment manufacturer to prevent condensation. Conduct routine inspections of stored equipment to check equipment condition.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate electrical equipment installation with other building components.

1. Arrange for chases, slots and openings in building structure during progress of construction to allow for electrical installations.
2. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
3. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the work. Coordinate installing large equipment requiring positioning prior to closing in the building.
4. Coordinate connecting electrical service to components furnished under other Sections.
5. Coordinate connecting electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.
6. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.
7. Coordinate installing electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.

B. Interruption of Power:

1. Contractor is advised that the project site is located at a fully operational airport. Unscheduled power interruptions to any of the electrical distribution systems are not allowed. Work requiring a temporary or permanent de-energizing of the electrical service shall be scheduled and approved in writing by the Contracting Officer's Technical Representative at least 14 calendar days in advance of performance of the work. Work may not commence until written authorization is received from the Contracting Officer's Technical Representative.

PART 2 - PRODUCTS

2.1 SUPPORTING DEVICES

A. Channel and angle supports, raceway supports, sleeves and fasteners shall be as specified in Section 26 05 29, “HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.”

2.2 ELECTRICAL IDENTIFICATION

A. Provide electrical identification as specified in Section 26 05 53, “IDENTIFICATION FOR ELECTRICAL SYSTEMS.” Manufacturer's standard products to use colors prescribed by ANSI A13.1 and NFPA 70.

B. Manufacturer's Nameplate: Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.3 SOIL MATERIALS

A. Sub-base Materials:

1. Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, or natural crushed sand.

B. Backfill and Fill Materials:

1. Materials complying with ASTM D 2487 soil classification groups GW, GP, GM, SM, SW, and SP; free of clay, rock or gravel larger than 2 inches in any dimension; debris; waste; frozen materials; and vegetable and other deleterious matter.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. All materials and equipment shall be installed in accordance with the contract drawings. Where manufacturer's recommended installation methods conflict with the contract requirements, difference shall be resolved by the Contracting Officer's Technical Representative. The installation shall be accomplished by skilled workers regularly engaged in this type of work. Where required by local regulation, the workers shall be properly licensed. Install components and equipment to provide the maximum possible headroom where mounting heights or other location criteria are not indicated. Install items level, plumb, and parallel and perpendicular to other building systems and components, except where otherwise indicated. Install equipment to facilitate service, maintenance and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations. Give right of way to raceways and piping systems installed at a required slope.

3.2 EXCAVATION FOR ELECTRICAL WORK

A. All excavations shall comply with OSHA requirements. Shore and brace as required for stability of excavation.

B. Sediment and Erosion Control:

1. Install sediment and erosion control measures in accordance with local codes and ordinances.

C. De-Watering:

1. Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding area. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain de-watering system components necessary to convey water away from excavations. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

D. Material Storage:

1. Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

E. Trenching:

1. Excavate trenches for electrical installations as follows:

   a. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of raceways and equipment.

   b. Excavate trenches to depth indicated or required.

   c. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.

   d. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations. The bedding material shall contain no particles that would be retained in a 1/4-inch sieve. Tamp the bedding material until firm.

F. Cold Weather Protection:

1. Protection excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F:

G. Backfilling and Filling:

1. Place soil materials in layers to subgrade elevations for each area classification listed below, using materials specified in PART 2 of this Section. Backfill excavations as promptly as work permits, but not until completion of inspection, testing, approval, and locations of underground utilities have been recorded; concrete formwork has been removed; shoring and bracing has been removed; voids have been backfilled; and trash and debris has been removed.

   a. Under walks and pavements, use a combination of sub-base materials and excavated or borrowed materials.

   b. Under building slabs, use drainage fill materials.

   c. Under piping and equipment, use sub-base materials where required over rock bearing surface and for correction of unauthorized excavation.

   d. Other areas, use excavated or borrowed materials.

H. Placement and Compaction:

1. Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

I. Before Compaction:

1. Moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified. Do not place backfill or material on surfaces that are muddy, frozen, or contain frost or ice.

J. Backfill Placement:

1. Place backfill and fill materials evenly adjacent to structures, piping and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately the same elevation in each lift.

K. Compaction:

1. Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated.

L. Percentage of Maximum Density Requirements:

1. Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density for soils which will not exhibit a well-defined moisture-density relationship (cohesion less soils).

a. For areas under walkways compact top 6 inches of sub-grade and each layer of backfill or fill material to 90 percent maximum density for cohesive material or 95 percent relative density for cohesion less material.

b. For other areas compact top 6 inches of sub-grade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils and 90 percent relative density for cohesion less soils.

M. Moisture Control:

1. Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during or subsequent to, compaction operations.

N. Subsidence:

1. Where subsidence occurs at electrical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions and replace surface treatment. Restore appearance, quality and condition of surface or finish to match adjacent areas.

3.3 INSTALLATION

A. The rules, regulations, and reference documents indicated shall be considered as minimum requirements and shall not relieve the Contractor from furnishing and installing higher grades of materials and workmanship than are specified or when required by the contract drawings. Equipment shall be installed in a manner to provide proper working space, access, and space for removal of the equipment to suit intended application.

B. Contract Drawings:

1. Where the drawings schematically indicate the work, diagrammatically or otherwise, furnish and install equipment, material and labor for a complete and proper installation. Ensure that electrical and communications work is coordinated and compatible with Architectural, Mechanical, Structural, and Civil work.

C. Firestopping:

1. Apply to cable and raceway penetrations of fire-rated floor and wall assemblies. Perform firestopping as specified in Section 07 84 13, “PENETRATION FIRESTOPPING” to re-establish the original fire resistance rating of the assembly at the penetration.

D. Fastening:

1. Unless otherwise indicated, securely fasten electrical items and their supporting hardware to the building structure in accordance with Section 26 05 29, “HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.”

E. Identification Devices:

1. Install identification devices where required in accordance with the requirements of Section 26 05 53, “IDENTIFICATION FOR ELECTRICAL SYSTEMS.”

F. Wiring Methods:

1. All wiring shall consist of insulated copper conductors installed in metallic raceways, unless otherwise specified.

G. Conductor Routing:

1. Panelboards, surge arresters, disconnect switches, etc., shall not be used as a raceway for conductor routing other than conductors that originate or terminate in these enclosures. Isolated ground conductors will be allowed to traverse these enclosures.

H. Conductor Separation:

1. Power conductors shall be routed separately from all other conductor types. Route power conductors and other conductors in separate raceways, or by a metallic divider between the power conductors and the other conductors in the same raceway. 480Y/277V power cables shall be in separate raceways from 208Y/120V power cables.

I. Neutral Conductor:

1. Shared/common neutrals shall not be permitted (i.e., each overcurrent device shall have its own separate neutral conductor). Neutral conductor sizes shall not be less than the respective feeder or phase conductor sizes.

J. Equipment Grounding Conductor:

1. Shared/common equipment grounding conductors shall not be permitted (i.e., each overcurrent protective device shall have its own separate equipment grounding conductor). The equipment grounding conductor shall be installed in the same conduit as its related branch and feeder conductors and shall be connected to the ground bus in the branch or distribution panelboard. Equipment grounding conductor shall be the same size as the phase conductors were indicated for special equipment branch or feeder circuits that require parity sized equipment grounding conductors to comply with equipment manufacturer's recommendations.

K. Cable Terminations:

1. Provide terminations in accordance with this Section and manufacturer's requirements. All splices (including those in the building) must be approved by the Contracting Officer's Technical Representative.

3.4 DEMOLITION

A. Protect existing electrical equipment and installations when performing new work. If damaged or disturbed in the course of the work, remove damaged portions and install new products of equal capacity, quality, and functionality. Remove demolished material from the project site. Remove, store, clean, re-install, reconnect, and make operational components indicated for relocation.

B. Accessible Work:

1. Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

C. Abandoned Work:

1. Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish. All wire not removed shall have the Contracting Officer's Technical Representative's written approval.

3.5 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for electrical installations. Perform cutting by skilled mechanics of the trades involved. Repair disturbed surfaces to match adjacent undisturbed surfaces.

3.6 FIELD TESTING

A. Perform the tests specified and other tests necessary to establish the adequacy, quality, safety, completed status, and suitable operation of each system. Repair or replace equipment that does not meet test requirements and retest. Tests shall be scheduled and approved in writing by COR at least 21 calendar days prior to conducting tests. Unless otherwise indicated, the Contractor shall furnish all test instruments, materials, and labor necessary to perform tests designated in Division 26 Sections. All tests shall be performed in the presence of the Contracting Officer's Technical Representative. All instruments shall have been calibrated within a period of 1 year preceding testing. Calibrations shall be traceable to applicable industry recognized standards.

B. Interim Operating and Performance Test:

1. Perform for each major equipment item after installation is complete and before the item is placed in service. After mechanical systems have been completely installed and balanced, test each system for proper operation. Tests shall be conducted in the presence of the Contracting Officer's Technical Representative under design conditions to ensure proper sequence of operation throughout the range of operation. Make adjustments as required to ensure proper functioning of the systems. Special tests on individual systems are specified under individual Sections. Provide 21 days written notice to the Contracting Officer's Technical Representative for major tests. Contractor shall demonstrate, to the Contracting Officer's Technical Representative's satisfaction, proper operation of control devices by simulating actual operating conditions. Devices tested shall include, but not be limited to, flow and pressure controls, temperature controls, and system interlocks and alarms.

C. Operation and Maintenance of Equipment:

1. After final tests and adjustments have been completed, fully instruct the Contracting Officer's Technical Representative and other personnel as directed by the Contracting Officer's Technical Representative in details of operation and maintenance of electrical equipment, including control systems and fire alarm system as installed.

D. Electrical Test Report:

1. Complete the Electrical Test Report included as Attachment No. 1. Provide the requested information for each panelboard and its power supply conductors. Perform insulation resistance tests in compliance with Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables" on wires including the neutral before connection to source and to loads. Perform the tests specified and other tests necessary to establish the adequacy, quality, safety, completed status, and suitable operation of each system. Repair or replace equipment that does not meet test requirements and retest. Notify the Contracting Officer's Technical Representative in writing 21 days prior to conducting tests.

E. Motor Insulation Resistance Test:

1. The manufacturer shall provide the following requested information for each 3-phase electrical squirrel cage, induction motor 1/2-horsepower (HP) and larger supplied to this project. Complete the Motor Test Report included as Attachment No. 2. Motors shall be tested for grounds and short circuits prior to being shipped to the job site. Windings shall test free from short circuits and ground. Minimum insulation resistance for motors, phase to phase to ground, shall not be less than 30 megohm measured within a 500 bolt DC insulation resistance tester. The manufacturer shall apply the test voltage for at least 1 minute after the reading has stabilized.

F. Electrical Main Supply and Distribution Feeders:

1. All electrical main supply and distribution feeders originating from switchboards, distribution panelboards, panelboards, or transformers, and all electrical feeders to 3-phase electrical squirrel cage, induction motor, 1/2-horsepower (HP) and larger, shall be tested for open/short circuits. All feeder circuit conduit shall be provided with grounding bushings. Submit the Electrical Test Report included as Attachment No.1.

G. Lighting, Power, Miscellaneous Power and Receptacle:

1. Lighting, power, miscellaneous power and receptacle single pole (1P) branch circuit panelboards, test any random 4 branch circuits (consisting of a phase conductor, a neutral and a grounding conductor) within a 42 pole panelboard or test one branch per every ten branch circuits. If more than 10 test points are above the specified value, then all branch line circuit wiring for both 120 volts and 277 volts shall be tested. Submit Attachment No.1, Electrical Test Report to the Contracting Officer's Technical Representative.

H. Other Tests:

1. All insulation resistance test, meggering, continuity tests, open and short circuiting testing that fail to meet the minimum standards as set forth in these electrical specifications shall have their feeder or branch circuit conductors (phase conductor, neutral and ground) removed and replaced. If after retesting, these feeder conductors fail to meet minimum requirements, the work shall be re-performed until such work and retesting passes the minimum design parameter requirements as set forth in these electrical specifications.

I. Circuit Breaker Tests:

1. No 120 volt, single pole (1P) 15-100 amp, or any 277 volt, single pole (1P), 15-150 amp, molded case circuit breaker is required to be tested. All two pole (2P) and all three pole (3P), molded case, insulated case and draw out power circuit breakers in both 208 volt and 480 volt ratings shall be tested for short circuit armature operation and for long term thermal overload protection operation to ascertain that they conform to within the manufacturer's recommended tolerances and design parameters. They shall be tested trip free of the handle operation, trip resetting and mechanical freedom of movement. The circuit breakers shall have factory recommended electrical insulation resistance and factory recommended electrical conductivity path resistance.

J. Load Balancing:

1. After the Contract Acceptance Inspection (CAI) of electrical systems, redistribute the loads where there is a greater than a 20 percent difference between readings in two or more phases, in accordance with Section 26 24 16, “Panelboards (NON-GFE).”

ATTACHMENT NO. 1

Electrical Test Report
Project Name
Sheet No.________of _______ Date

Project No._________________________________Address _______________________________________

SERVICE TRANSFORMER SIZE			
NL SERVICE VOLTAGE			
FL SERVICE VOLTAGE			
PANEL OR SWBD SERVED FROM			
PANEL OR SWITCHBOARD			
LOCATION			
MANUFACTURER			
TYPE			
FEEDER OC PROTECTION			
FEEDER CONDUCTOR SIZE			
GROUND CONDUCTOR SIZE			

MEASURED CONDITIONS	PHASE			PHASE			PHASE		
	A	B	C	A	B	C	A	B	C
NO LOAD FEDDER VOLTAGE									
OPERATING LOAD FEEDER VOLTAGE									
OPERATING LOAD FEEDER CURRENT									
CONDUCTOR INSUL RESISTANCE Ø AB									
CONDUCTOR INSUL RESISTANCE Ø BC									
CONDUCTOR INSUL RESISTANCE Ø CA									
CONDUCTOR INSUL RESISTANCE TO GROUND									
NEUTRAL INSUL RES TO GR W/GR CONN REMOVED									

ATTACHMENT NO.2

Motor Test Report
Project Name
Sheet No.________of _______ Date

Project No.________________________________Address
____

DESTINATION		
LOCATION		
HORSEPOWER		
NEMA STARTER SIZE		
STARTER MFG & CAT NUMBER		
HEATER CAT NUMBER		
MAXIMUM HEATER AMPS		
CONDUCTOR SIZE		
GROUND SIZE		
SERVED FROM PNL OR MCC		

MEASURED CONDITIONS	PHASE				PHASE		
	A	B	C		A	B	C
ACTUAL MOTOR CURRENT							
NAMEPLATE MOTOR CURRENT							
NO LOAD VOLTAGE							
FULL LOAD VOLTAGE							
CONDUCTOR INSUL RESISTANCE Ø AB							
CONDUCTOR INSUL RESISTANCE Ø BC							
CONDUCTOR INSUL RESISTANCE Ø CA							
CONDUCTOR INSUL RESISTANCE TO GROUND							

END OF SECTION 26 05 00

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SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes building wires and cables and associated splices, connectors, and terminations for wiring systems rated volts and less.

1.2 REFERENCE STANDARDS

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

B. Federal Specifications (FS)

1.	FS QQ-W-343	Wire, Electrical, Copper (Uninsulated), with Notice 1
2.	FS W-S-610	Splice Connectors

C. National Fire Protection Association (NFPA)

1.	NFPA 70	National Electrical Code

D. National Electrical Manufacturers Association (NEMA)

1.	NEMA WC3	Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
2.	NEMA WC70	Non-Shielded Power Cable 2000 V or Less

E. Underwriters Laboratories (UL)

1.	UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
2.	UL 486C	Standard for Splicing Wire Connectors
3.	UL 486E	Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

F. American Society for Testing and Materials (ASTM)

1.	ASTM B 8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
2.	ASTM D 1000	Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes used for electrical and electronic applications.

G. International Electrical Testing Association (NETA)

1.	NETA ATS	Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems

H. National Electrical Contractors Association

1.	NECA	Standard of Installation

I. Occupational Safety and Health Administration (OSHA)

1.	29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

1.3 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, “SUBMITTAL PROCEDURES.”

B. Test Reports: Field test reports indicating and interpreting test results relative to compliance with performance requirements of testing standard.

C. Operation and Maintenance Data: Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “OPERATION AND MAINTENANCE DATA.”

1.4 QUALITY ASSURANCE

A. Testing Firm Qualifications: An independent testing firm shall meet OSHA criteria for accreditation of testing laboratories, 29 CFR 1910.7, or shall be a full member company of the International Electrical Testing Association (NETA).

B. Testing Firm's Field Supervisor Qualifications: A person currently certified by the NETA National Institute for Certification in Engineering Technologies to supervise on-site testing specified in PART 3.

C. Components and Installation: Comply with NFPA 70, for components and installation.

D. Listed and Labeled: Provide products specified in this Section that are listed and labeled. The terms "Listed" and "Labeled" as defined in NFPA 70, Article 100.

E. Listing and Labeling Agency Qualifications: A NRTL as defined in 29 CFR 1910.7.

F. Installer Qualifications: Cable splices shall be performed by experienced and qualified cable splices. The workman shall be licensed if required by the authority having jurisdiction.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate layout and installation of cable with other installations. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Contracting Officer's Technical Representative.

PART 2 - PRODUCTS

2.1 BUILDING WIRES AND CABLES

A. Specified Applications: UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in PART 3.

B. Rubber Insulation: Conform to NEMA WC3.

C. Thermoplastic Insulation: Conform to NEMA WC70, NEMA WC71, and NEMA WC74. Shall be type THHN/THWN. Service entrance use SE cable only.

D. Stranded Conductors: Solid copper conductor for 10 AWG and smaller; stranded copper conductor for larger than 10 AWG. Stranded conductors rating shall be tin coated, ASTM B 8, Class B.

E. Wire and Conduit Sizes: All wire and conduit sizes are based on copper insulated conductors with 75 degrees C temperature rating and ambient temperature of 30 degrees C. Minimum conduit size shall be 3/4".

F. Sizes: Minimum 12 AWG. Minimum 10 AWG for 120 volt circuits where circuit length (one way) exceeds 75 feet form source, and 10 AWG for 277 volt circuits where circuit length (one way) exceeds 150 feet from source. Communication systems wiring size shall be in accordance with manufacturer's requirements.

1. Stranded conductors shall be used with wire compression connectors or a pressure washer type lug.
2. Conductor Type
3. Soft drawn, annealed copper (aluminum conductors are not acceptable).
4. Power conductors shall be single conductor type. (< #1/0 ; > #1/0 parallel cond. allowed)
5. Control interconnection between equipment shall be jacketed type multi-conductor.
6. Instrumentation conductor shall be twisted pair, shielded, jacketed type.
7. Conductors used for lighting and receptacle branch circuits shall be single conductor type.

G. Conductor Color Codes: Refer to Section 26 05 53, "IDENTIFICATION FOR ELECTRICAL SYSTEMS" for conductors No. 4 AWG and larger, where factory color- coding is not available. Feeder conductors to panels and three phase circuits shall be factory color coded as follows:

1. 208/120 (240) Volt System:
   a. Phase A: Black
   b. Phase B: Red
   c. Phase C: Blue
   d. Neutral: White
   e. Ground: Green

1. 480/277 Volt System:
   a. Phase A: Yellow
   b. Phase B: Brown
   c. Phase C: Orange
   d. Neutral: Gray

e. Ground: Green

2. Single-phase branch circuits shall be factory color coded as stated above, or identified in accordance with Section 26 05 53, “IDENTIFICATION FOR ELECTRICAL SYSTEMS.”

3. Control cables shall be IAW NEMA WC50

H. Ground Conductors: Un-insulated conductors shall be copper and comply with FS QQ-W-343.

I. Cables not permitted: MC Cable, AC cable, and SO cord.

2.2 CONNECTORS AND SPLICES

A. UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for applications and for service indicated. Select to comply with project's installation requirements and as specified in PART 3.

B. Connectors, Splice Sleeves, and Terminal Lugs: Wire and cable connectors, lugs, and sleeves shall be in compliance with UL 486A, and the following:

1. For splices of 10 AWG and smaller building wires in lighting circuits, use tin plated copper compression type connector caps with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
2. Use ring tongue compression type terminators with insulated barrel on all stranded conductors used in control wiring.
3. Crimp type connectors are not permitted on solid conductors.

C. Insulating Tape: ASTM D 1000. As a minimum, rate equal to conductor insulation. Rubber tape shall be silicon rubber with silicon pressure sensitive adhesive.

D. Bundling Straps: Nylon straps with a locking hub or head on one end and a taper on the other.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine raceway and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Verify that the duct or conduit is open, continuous, and clear of debris before installing cable. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Feeders: Type THHN/THWN, copper conductor, in raceway.

B. Indoor Branch Circuits: Type THHN/THWN, copper conductor in raceway. Use this conductor for lighting and receptacle circuits in dry locations only.

C. Exterior Branch Circuits: Type THWN, copper conductor in raceway.

D. Fire Alarm Power Circuits: Type THHN/THWN, copper conductor in raceway.

E. Communications System Wiring: Communications System wiring (to include telephone cable, fire alarm cable, security wiring, inter-communication wiring and public address/music system) shall be as specified under applicable sections and specified requirements of NFPA 70. Use copper wire or fiber optics cable only. Aluminum wire is not permitted.

F. Service Entrances: Type XHHW/XHHW-2 conductor rated for SE, USE or USE-2, single conductors in raceway.

G. Emergency circuits: 2 hour fire rated Lifeline RHW (or equal), includes circuits feeding elevator, stair pressurization fan, fire pump, and tower stairwell lighting

3.3 INSTALLATION

A. Install wires and cables as indicated, according to manufacturer's written instructions and NECA. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.

1. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation, and must be non-flammable.
2. Use pulling means; including fish tape, cable, rope, and basketweave wire/cable grips that will not damage cables or raceway.
3. Bend to radii not less than the minimum bending recommended by manufacturer or 12 times the outer diameter of cable. Do not exceed the pulling tension recommended by manufacturer.
4. All box connectors shall have insulated throat box connector.

B. Cable shall be installed in a manner to prevent harmful stretching of the conductor, injury to the insulation or damage to the outer protective covering. Install exposed cable, parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible. The ends of cables shall be sealed with moisture-seal tape before pulling, and it shall be left sealed until connections are made.

C. Conductor Splices: Keep to a minimum.

D. No splices shall be allowed on critical circuits and feeders, or in any square wireway (essential or critical).

E. Splices shall be made only at outlets, junction boxes, or accessible raceways.

F. Wire nuts may only be used to splice conductors sized No. 10 AWG and smaller.

G. Compression connectors shall be used to splice conductors No. 8 AWG and larger.

H. All splices, including those made with insulated wire nuts, and shall be insulated with electrical tape or heat-shrink tubing to a level equal to that of the factory insulated conductors.

I. Splicing of any conductors in panelboards is not permitted.

J. Splices shall be made with solderless connectors conforming to UL 486A, UL 486C, UL 486E and FS W-S-610.

K. Install splices and insulating tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.

L. Use splice and tap connectors that are compatible with conductor material.

M. Splice methods and material shall be of a type recommended by the manufacturer of the splicing material for the particular type of cable being spliced and shall be approved by the Contracting Officer's Technical Representative prior to installation.

N. Wiring at Outlets: Install with at least 6 inches of slack conductor at each outlets.

O. Connecting Outlets and Components: Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL 486A.

P. Cable/Conductor Installation: Cables/Conductors sized 250 kCMIL and greater shall be installed with the sue of a hydraulic cable bender. Cable supports shall be required for stress relief. A splice shall not be pulled into a duct or conduit under any circumstance.

Q. Neutral and Ground: Separate neutral and ground wires shall be provided for each over current protection device. Each branch circuit shall have its own neutral and ground conductor. Common neutral or ground is not acceptable. Neutral conductors shall extend from the neutral bus where the phase conductors originate. Install conductors only after the raceway system is complete.

R. Electrical Identification: Install electrical identification devices specified in Section 26 05 53, “IDENTIFICATION FOR ELECTRICAL SYSTEMS” at terminations, immediately after installing wires and cables.

3.4 FIELD QUALITY CONTROL

A. Testing, General:

1. Cables shall be tested prior to installation and again upon completion of the installation. Testing shall be accomplished before connection is made. Tests shall be performed in the presence of the Contracting Officer's Technical Representative.
2. Upon installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test state in NETA ATS. Certify compliance with test parameters.
4. Test wire and cable for continuity or circuitry, and also for short circuits.

B. Insulation Resistance Tests: Feeder and branch circuit insulation tests shall be performed after installation, but before connection to equipment.

1. Conductors shall test free from short circuits and grounds, and have a minimum phase-to-phase and phase-to-ground insulation resistance of 30 mega-ohms when measured with a 500-volt DC insulation resistance. The Contractor shall submit a letter type test report to the COR prior to final inspection of the work. The report shall list the tests performed and results obtained.
2. Apply the test voltage for at least one minute after motor reading his stabilized.

C. Malfunctioning Products: Correct malfunction products at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

ATTACHMENT

Megger Test Report:

600 V CABLE INSULATION AND CONTINUITY TEST (power/control wire & cable)

Project Name________________Date_________________Sheet No._______of _____
Project No.______________________Address ____________________________________

NOTE: 500 VOLT MEGOHMETER, MEGGER ALL PHASES, RECORD MINIMUM READING

Panel No. Ckt. No. Feeder No.	VOLTS	A-B	A-C	B-C	A-N	B-N	C-N	A-G	B-G	C-G	N-G	Supervisor O.K.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment**.**

1.2 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

B. FAA Specifications and Standards

1.	FAA-STD-19e	Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements For Facilities and Electronic Equipment
2.	FAA-STD-020a	Transient Protection, Grounding Bonding and Shielding for Electronic Equipment
3.	6950.19b	Practices and Procedures for Lightning Protection, Grounding, Bonding and Shielding Implementation
4.	6950.20a	Fundamental Considerations of Lightning Protection, Grounding, Bonding and Shielding

C. National Fire Protection Association (NFPA)

1.	NFPA 70	National Electrical Code
2.	NFPA 780	Standard for the Installation of Lightning Protection Systems

D. Institute of Electrical and Electronics Engineers (IEEE)

1.	IEEE 1100	Powering and Grounding Sensitive Electronic Equipment
2.	IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
3.	IEEE C62.41	Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

E. Underwriters Laboratories (UL)

1.	UL 467	Grounding and Bonding Equipment
2.	UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors

F. American Society for Testing and Materials (ASTM)

1.	ASTM B 3	Standard Specification for Soft or Annealed Copper Wire
2.	ASTM B 33	Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
3.	ASTM B 8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

G. Occupational Safety and Health Administration (OSHA)

1.	29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

1.3 SUMMARY

A. This Section includes solid grounding of electrical systems and equipment and basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other Sections of this Specification. Grounding requirements for FAA-occupied spaces often exceed NFPA 70 criteria. Install grounding systems in accordance with this Section and as indicated on the drawings.

1.4 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, “SUBMITTAL PROCEDURES:”

B. Product Data:

1. Connectors and Connection Materials
2. Grounding Fittings
3. Qualifications
4. Qualification data for firms and persons specified in "QUALITY ASSURANCE" article to demonstrate their capabilities and experience. Include lists of complete projects with project names and addresses, names and addresses of architects and owners, and other information specified.

C. Test Reports:

1. Field Tests and Observation Reports: Certified by the testing organization and indicating and interpreting the test reports for compliance with performance requirements.

D. Operation and Maintenance Data: Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “OPERATION AND MAINTENANCE DATA.”

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: A nationally recognized testing laboratory as defined by 29 CFR 1910.7, or a full member company of NETA.

B. Testing Agency Field Supervision: Use persons currently certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in PART 3. Comply with NFPA 70 and UL 467.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled as defined in NFPA 70, Article 100.

1. Listing and Labeling Agency: Qualifications as defined in 29 CFR 1910.7.

PART 2 - PRODUCTS

2.1 WIRING AND CABLE GROUNDING CONDUCTORS

A. Comply with Section 26 05 19, “LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.” Conform to NFPA 70, except as otherwise indicated for conductor properties, including stranding.

B. Material: Copper. Use only copper wire for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

C. Size: Comply with FAA-STD-19e.

D. Equipment Grounding Conductors (EGC): Insulated with green color insulation. Insulated conductors larger than #6AWG with black color insulation shall be allowed to be re-identified with green tape.

1. The equipment grounding conductor shall be routed in the same raceway as its’ related phase and neutral conductors. Cord-connected equipment requiring an equipment ground shall include the equipment grounding conductor as an integral part of the power cord. Where power is supplied to electronic equipment through a cable and connector, the connector shall contain a pin to continue the equipment grounding conductor to the equipment chassis. Conduit or cable shields shall not be used as the equipment grounding conductor.
2. Parity-sized equipment grounding conductors (same size as the associated phase conductors) shall be used when it is recommended as good practice in a manufacturer’s equipment installation requirements. Where a parity-sized equipment grounding conductor is required, the resulting size equipment grounding conductor shall be maintained as the minimum size permitted upstream to the source of a separately derived system – or – in the absence of an intervening separately derived system, all the way back to the service entrance. The parity size equipment grounding conductor shall be bonded to bonding bushings at each end of each raceway section with a bonding jumper the same size as the initially established minimum size equipment grounding conductor – installed as shown by Figure I. Note: Where flexible metal conduit is encountered, liquid tight flexible metal conduit must be used – which provides a bonding terminal integral to an end connector listed for grounding.

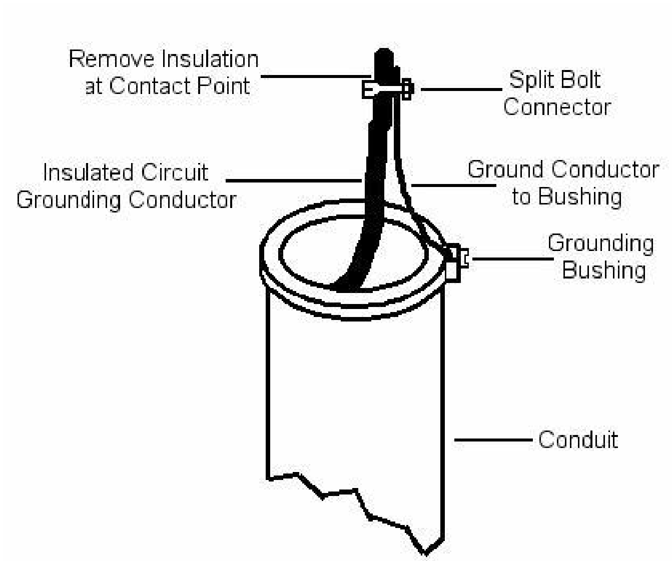

Figure I – Bonding of Conduit and Equipment Grounding Conductor

3. Grounding terminals in all receptacles on multi-outlet assemblies shall be hardwired to an equipment grounding conductor. Strips that depend upon serrated or toothed fingers for grounding shall not be used.
4. All flexible metal conduits shall be provided with an external bonding jumper in addition to the internal equipment grounding conductor. Therefore, liquid tight flexible metal conduit must be used where any flexible metal conduit is required – as in paragraph 2) preceding. The bonding jumper shall be a 6 AWG green-insulated stranded copper conductor – or the largest jumper the conduit grounding bushing permits. The bonding jumper shall terminate on fittings listed for grounding at each end of the liquid tight flexible metal conduit.
5. A separate equipment grounding conductor shall be provided for each overcurrent device and as required by the NEC.
6. All metallic boxes shall include a grounding pigtail (#12 minimum) connected to the EGC.

E. All feeder circuits for power panels shall have their equipment grounding conductor connect to a ground bushing.

F. Underground Conductors: Bare, tinned, stranded, except as otherwise indicated.

G. Bare Copper Conductors: Conform to the following:

1. Solid conductors: ASTM B 3.
2. Assembly of stranded conductors: ASTM B 8.
3. Tinned conductors: ASTM B 33.

2.2 MISCELLANEOUS CONDUCTORS

A. Grounding Bus: Bare, annealed-copper. Size as indicated on drawings.

B. Braided Bonding Jumpers: Where electrical continuity across the shock mounts is necessary, bonding jumpers shall be installed across each shock mount. Jumpers of this application should have a maximum thickness of 0.025-inch, so that the damping efficiency of the mount is not impaired. In severe shock and vibration environments, solid straps may be corrugated, or flexible wire braid may be used. Braids are to be terminated with copper ferrules.

C. Raceway Bonding Jumpers: Copper, minimum size #6 AWG unless otherwise noted.

2.3 CONNECTOR PRODUCTS

A. Exothermic-Welded Connections: Provided in kit form and selected per manufacturer's written instructions for specific types, sizes, and combinations of conductors and connected items.

2.4 POWER DISTRIBUTION SYSTEM GROUNDING

A. The facility electrical grounding shall comply with NFPA 70. The electronic ground systems shall not replace or be used in lieu of the power distribution system grounding conductors.

2.5 ATCT POWER DISTRIBUTION SYSTEM GROUNDING

A. Power Distribution Sources for Tall Towers: All power distribution for the areas at the top of the ATCT shall be via separately derived sources (transformers). These transformers shall be grounded in accordance with the requirements of NFPA 70. The grounding electrode conductor (GEC) specified in NFPA 70 shall be connected to the grounded and grounding conductors at the first system disconnecting means or overcurrent device. This point of connection is mandated to facilitate the effective installation of a surge protective device (SPD). An SPD rated at 80 kA (8x20 microsecond current waveform) surge capacity or greater, suitable for location category C3 per IEEE C62.41, and providing protection L-L and L-N shall be installed on the load side of the first disconnecting means or overcurrent device of each separately derived system. The ground bus at the first disconnecting means or overcurrent device shall be bonded to the ATCT Junction Level main ground plate established in accordance with the requirements of paragraph above. This connection shall not be in lieu of the grounding electrode conductor requirements of NFPA 70. Grounding electrode conductor in PVC conduit.

PART 3 - EXECUTION

3.1 APPLICATION

A. Equipment Grounding Conductors: All metallic non-current carrying parts of electrical equipment shall be grounded with equipment grounding conductors whether or not shown on the drawings. Equipment grounding conductors shall be green insulated copper conductors unless otherwise indicated. When these conductors are not sized nor shown on the contract drawings, size them in accordance with NEC 250.122. In no case, however, shall these conductors be smaller than No. 12 AWG. Install green, equipment grounding conductor with all feeder and branch circuit conductors.

1. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and above, including air cleaners and heaters. Bond conductor to each unit and to air duct.
2. Water Heater, Heat-Tracing, and Anti-frost Heater Circuits: Install a separate equipment grounding conductor to each electric water heater, heat-tracing assembly, and anti-frost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

B. Signal and Communication Systems:

1. Service Locations and Wiring Closets: Terminate grounding conductor on a multiport ground plate.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
3. Enclosures: Ground all enclosures of electrical and electronic wiring and distribution equipment in accordance with requirements of NFPA 70.
Facility Level Transient Suppression: Facility level transient suppression components for signal, data, and control lines shall be installed either where the land lines enter the facility or at the demarcation point where the lines transfer to FAA control.

C. Grounding bushing, indoors: Provide grounding bushing on all feeder conduits (both ends and junction boxes in between) for power distribution system.

D. Conduit or Cable Shields: Conduit or cable shields shall not be used as the equipment grounding conductor.

E. Metallic Non-current Carrying Parts: All metallic non-current carrying parts of electrical and mechanical equipment throughout the facility shall be bonded by welding with a separate equipment grounding conductor, #4 AWG (with green insulation) or larger and connected to the multipoint ground system. All metallic non-current carrying parts of electrical and mechanical equipment shall be grounded with equipment grounding conductors whether or not shown on the drawings.

3.2 INSTALLATION

A. The grounding requirements exceed those of NFPA 70. Grounding system shall be as indicated on the contract drawings and as specified herein. Reference FAA-STD-019e and IEEE 1100 when installing equipment. In no case shall NFPA 70 be violated.

B. Grounding Conductors: Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact or damage.

C. Equipment Enclosure Grounding:

1. Ground lugs shall be mounted on clean, bare metal surfaces that are free of paint, rust, etc. All ground lugs shall be of a noncorrosive material suitable for use as a grounding connection, and must be compatible with the type of metal being grounded. Bare wire, wrapped around connecting screws or mounting bolts and screws is not acceptable as a grounding connection.

D. Interior Metal Piping and Air Ducts: Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

E. Fault Protection: Prevent equipment parts subject to human contact during operation and maintenance from being electrically energized when powering faults or components fail. Ground parts with a low impedance path to the chassis or cabinets in which they are mounted.

3.3 CONNECTIONS

A. Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series. Make connections with clean, bare metal at points of contact. Coat and seal connections having dissimilar metals with inert materials to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Use for connections to structural steel, for underground connections, ground plates and where indicated on drawings. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Terminations: Terminate insulated equipment grounding conductors for feeders with pressure-type grounding lugs. Where metallic raceways terminate at nonmetallic or nonconductive housings, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

D. Raceway Grounding: Surface metal raceways, wireways, or cable tray systems shall be installed in a manner that ensures electrical continuity. Insulated copper bonding jumpers shall be installed between adjacent raceway sections to ensure proper bonding. Uninsulated conductors shall not be used. Unless otherwise indicated, the minimum size for these bonding jumpers shall be #6 AWG. All metallic raceway penetrations into a facility structure shall be bonded to the earth electrode system.

E. Tightening of Connectors: Tighten grounding and bonding connectors and terminators, including screws and bolts, in accordance with torque tightening values specified in UL 486A.

F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Mechanical connections using a Burndy "Hyground Connector", Thomas and Betts Compression Connector or FAA approved equivalent equipment when operated at the manufacturer's recommended pressure to develop a minimum force of 12 tons is acceptable as approved pressure connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on ground conductor. Hydraulically crimped connectors are not acceptable in the lightning protection system.

3.4 FIELD QUALITY CONTROL

A. Independent Testing Agency: Engage an independent electrical testing organization to perform tests described below. Ensure no connection to utility power is made during testing.

1. Tests: Subject the completed grounding system to a test using a fall-of-potential method at system ground well, where a 10 ohm measurement is required. Measure ground resistance not less than 2 full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the 2-point method in accordance with IEEE 81.

a. Earth electrode system ground shall not exceed 10 ohms.

b. All grounds, bonds, and continuity tests that fail to meet the minimum standards and resistivity levels as set forth in these electrical specifications shall have their materials removed and replaced and shall have all workmanship redone. If after retesting they fail to meet minimum requirements, the work shall be redone until such work and retesting passes the minimum design parameter requirements.

c. All sections of joined conduit, cable tray, or structural steel columns and beams shall have the first 10 consecutive connections of each system tested for continuity/grounding/bonding. If they test within acceptable limits, then test every 10th consecutive connection thereafter. If any test point is higher than specified in these electrical sections then test the next 10 consecutive connections and/or as many points as required to get a satisfactory reading below the specified rating. If more than 10 test points of each system are above the specified values, then all continuity/grounding/bonding points in that system shall be tested.

B. Report: Prepare test reports, certified by the testing organization of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results.

3.5 ADJUSTING AND CLEANING

A. Restore surface features, including vegetation, at areas disturbed by work of this Section. Reestablish original grades, except as otherwise indicated. Where sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include top soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 26 05 00, “COMMON WORK RESULTS FOR ELECTRICAL.” Maintain restored surfaces.

END OF SECTION 26 05 26

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

1.2 REFERENCE STANDARDS

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

B. ASTM International (ASTM)

1.	ASTM A 36	Standard Specification for Carbon Structural Steel
2.	ASTM A 53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

C. National Fire Protection Association (NFPA)

1.	NFPA 70	National Electrical Code

D. Underwriters Laboratories (UL)

1.3 SUBMITTALS

A. Product data for each type of product specified.

1.4 QUALITY ASSURANCE

A. Electrical Component Standards: Components and installation shall comply with NFPA 70. Electrical components shall be listed and labeled by UL or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 - PRODUCTS

2.1 COATINGS

A. Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Product for use outdoors shall be stainless steel.

2.2 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Carbon steel wedge or sleeve type.
2. Toggle Bolts: All steel springhead type.
3. Powder Actuated Fasteners: Not Allowed.

C. U-Channel Systems: 16-gauge steel channels, with 9/16-inch diameter holes, at not more than 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacturer.

D. Conduit Sealing Bushings: Factory-fabricated assembly consisting of threaded body and insulating wedging-plug for non-armored electrical cables in conduits subject to exposure to water and/or oil penetration at conduit joints. Provide plugs with number and size of conductor gripping holes as required to suit installation. Construct body of malleable iron casting with hot-dipped galvanized finish. Support systems shall be capable of carrying the weight of the box and its contents.

E. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat end lock washers. Provide steel channel supports with 9/16-inch diameter holes at not more than 8 inches on center, in at least one surface. Fittings and accessories to mate and match with channels and to be from the same manufacturer.

2.3 FABRICATED SUPPORTING DEVICES

A. General

1. Shop or Field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with welded spiral seams or welded longitudinal joint. Fabricate sleeves from the following gauge metal for sleeve diameter noted:

a. 3-inch and smaller: 20-gauge
b. 4-inch to 6-inch: 16 gauge
c. Over 6-inch: 14 gauge
d. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.

D. Supplementary Structural Supports: ASTM A 36 steel shapes.

1. Supports and supporting devices shall be designed and installed to withstand the local code equivalent of a minimum UBC Seismic Zone 4 force.
2. Provide the installation of supplementary structural supports required for attachment of hangers and other devices supporting electrical equipment and conduits.
3. Members welded to main structural members shall be equal to the specification for the main structural member.
4. Size support members for their actual loads and safety factors without excessive deflection and with consideration for rigidity under vibration.
5. Provide seismic lateral bracing for all unistrut assemblies, at 20 foot intervals. See drawings for typical details.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NFPA 70. Coordinate with the building structural system and with other electrical installation.

B. Raceway Supports: Comply with NFPA 70 and the following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.
2. Strength of each support shall be adequate to carry design load plus 25 percent for future use, multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 pounds, provide additional strength until there is a minimum of 200 pounds safety allowance in the strength of each support.
3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceway. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1 1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
6. Space supports for raceway in accordance with Table I of this Section. Space supports for raceway types not covered by the above in accordance with NFPA 70.
7. Support exposed and concealed raceway within 1-foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or thread-less box connectors.
8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors are carried entirely by the conduit supports with no weight load on raceway terminals.
9. Neither raceways nor boxes shall be fastened to suspended ceiling supports.
10. Cable tray support (uni-strut) shall run the entire length of the Electronic Equipment and Telco Rooms so that the uni-strut is one continuous piece from wall to wall.

C. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panel boards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

D. Open Overhead Spaces: In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches form the box. Cast metal boxes having thread-less connectors and sheet-metal boxes shall be supported directly from the building structure or by bar hangers.

E. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceway and cable installations. For sleeves through fire-rated wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.

F. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panel boards, transformers, boxes, disconnect switches, lighting fixtures, and control components in accordance with the following:

1. Fasten by means of wood screws, nails, screw-type nails, carriage bolts, or lag screws of equal holding strength on wood; toggle bolts on hollow masonry units concrete inserts or expansion bolts on concrete or solid masonry; and machine screws, welded threaded studs, or spring-tension clamps on steel. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
2. Holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4-inch in concrete shall not cut the main reinforcing bars. Patch holes that are not used with like and kind materials.
3. Coordinate any cutting or boring of structural beams with Structural Engineer prior to any work being done.
4. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.
5. Coordinate with structural engineer on expansion joints used to support raceway.

3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS

HORIZONTAL RUNS Conduit size & number of conduits in run	Location	RMC & IMC (1)	EMT (1)
1/2, 3/4 - 1 or 2	Flat ceiling or wall.	5	5
1/2, 3/4 - 1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7
1/2, 3/4 - 3 or more	Any location.	7	7
1 & larger	1 or 2 flat ceiling or wall	6	6
1 & larger	1 or 2 where it is difficult to provide supports except at intervals fixed by the building construction	10	10
1 & larger	3 or more any location	10	10
Any	Concealed	10	10
VERTICAL RUNS			
1/2, 3/4	Exposed	7	7
1, 1-1/4	Exposed	8	8
1-1/2 and larger	Exposed	10	10
Up to 2	Shaftway	14	10
2-1/2	Shaftway	16	10
3 & larger	Shaftway	20	10
Any	Concealed	10	10

NOTES:

(1) Maximum spacing of supports (feet).

(2) Maximum spacing for IMC above apply to straight runs only. Otherwise, the maximums for EMT apply.

(3) Maximum support from boxes shall be within 3 feet.

Abbreviations:
EMT: Electrical metallic tubing
IMC: Intermediate metallic conduit
RMC: Rigid metallic conduit
Maximum: The defined distance or less.

END OF SECTION 26 05 29

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SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

B. American National Standards Institute (ANSI)

1.	ANSI C80.1	Rigid Steel Conduit, Zinc-Coated
2.	ANSI C80.3	Electrical Metallic Tubing, Zinc-Coated
3.	ANSI C80.6	Intermediate Metal Conduit Zinc-Coated

C. FAA Standards (FAA)

1.	FAA 1217f	Electrical Work, Interior
2.	FAA STD 019e	Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment

D. Federal Specifications (FS)

1.	WW-C-566	Conduit, Metal flexible

E. National Electrical Contractors Association (NECA)

1.	NECA	Standard of Installation

F. National Electrical Manufacturers Association (NEMA)

1.	NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
2.	NEMA FB1	Fitting, Cast Metal Boxes, and Conduit Bodies, and Cable Assemblies
3.	NEMA ICS-6	Industrial Control System Enclosure
4.	NEMA OS1	Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
5.	NEMA RN1	Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit

G. National Fire Protection Association (NFPA)

1.	NFPA 70	National Electrical Code

H. Occupational Safety and Health Administration (OSHA)

1.	29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

I. Underwriters Laboratories (UL)

1.	UL 1	Flexible Metal Conduit
2.	UL 1242	Intermediate Metal Conduits
3.	UL 360	Liquid-tight Flexible Metal Conduit
4.	UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
5.	UL 5	Surface Metal Raceways and Fittings
6.	UL 50	Enclosures for Electrical Equipment
7.	UL 514A	Metallic Outlet Boxes
8.	UL 514B	Fittings for Conduit and Outlet Boxes
9.	UL 6	Rigid Metal Conduit
10.	UL 797	Electric Metallic Tubing
11.	UL 870	Wireways, Auxiliary Gutter, and Associated Fittings

J. Steel Structures Painting Council (SSPC)

1.	SSPC PS-10.01	Hot-Applied Coal Tar Enamel Painting System

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring. Refer to Section 26 05 26, “GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS” for related grounding requirements.

1.3 RACEWAY COMPONENTS

A. Raceways include the following:

1. Rigid metal conduit (RMC).
2. Electrical metallic tubing (EMT).
3. Flexible metal conduit (FMC).
4. Liquidtight flexible conduit (LFMC).
5. Wireway.
6. Rigid nonmetallic conduit.

1.4 BOXES, ENCLOSURES AND CABINETS

A. Boxes, enclosures, and cabinets include the following:

1. Device boxes.
2. Outlet boxes.
3. Pull and junction boxes.
4. Conduit bodies.
5. Cable access boxes.
6. Cabinets and hinged cover enclosures.

1.5 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, "SUBMITTAL PROCEDURES":

1. Nonstandard boxes, enclosures and cabinets: Include layout drawings showing components, wiring, supports, and seismic bracing.
2. Surface raceway
3. Wireway and fittings
4. Hinged cover enclosures and cabinets
5. Operation and Maintenance Data: Submit in accordance with Section 01 78 23, "OPERATION AND MAINTENANCE DATA."

1.6 QUALITY ASSURANCE

A. Comply with the latest edition of NFPA 70 for components and installation. Boxes shall be sized in accordance with NFPA 70 Article 376. Comply with NECA.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled. The terms "Listed and Labeled" as defined in NFPA 70 Article 100.

C. Listing and Labeling Agency Qualifications: A NRTL as defined in 29 CFR 1910.7.

D. Layout Coordination: Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance and access. All outdoor boxes shall be rated minimum NEMA 4X.

PART 2 - PRODUCTS

2.1 GENERAL

A. Enclosures shall conform to NEMA standards. All materials procured under this Section shall be in accordance with FAA 1217f and FAA STD 019e.

2.2 METAL CONDUIT AND TUBING

A. Rigid Metal Conduit (RMC): ANSI C80.1 and UL 6.

B. Plastic-Coated Steel Conduit and Fittings: NEMA RN1.

C. Electrical Metallic Tubing (EMT) and Fittings: UL 797 and ANSI C80.3 with compression-type fittings. Screw-type fittings are not acceptable. Use for lighting, building power, fire alarm, environmental and communication circuits in concealed areas where not subject to physical damage, such as suspended ceilings, furred walls and raised floors. Connectors shall have insulated-throat, smooth bell shaped end. Shall not be used in exterior locations, in concrete, or interior exposed below 8 ft (except in electrical chase).

D. Flexible Metal Conduit (FMC): Zinc-coated steel; UL 1 and WW-C-566. Conduit and fittings shall be type listed for grounding. Provide FMC in minimum 24 inches or 10 diameter lengths for connection to motors and equipment subject to vibration and movement.

E. Liquidtight Flexible Metal Conduit (LFMC): Flexible steel conduit with PVC jacket, listed for grounding; UL 360.

F. Rigid Non-Metallic Conduit: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

G. Fittings: NEMA FB1 and UL 514B, compatible with conduit and of the threaded type. Set screw fittings are not allowed. Conduit expansion and deflection fittings shall be watertight. Fabricate from material compatible with conduit to be used. Expansion and deflection fittings shall be equipped with bonding jumper cable to provide electrical continuity. Lock-nut and bushings inside boxes or enclosures shall be grounding type.

H. Underground Fittings: Shall be protected by field wrapping, 0.01-inch thick pipe wrapping plastic tape applied with 50 percent overlap.

2.3 WIREWAYS

A. Material: Minimum 16 gauge sheet steel sized and shaped as indicated.

B. Fittings and Accessories: UL 870. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps and other fittings to match and mate with wireway as required for complete system. Provide ground bushings on all conduit terminations to wireways and galvanized rigid steel as indicated in PART 3 of this Section. Select features where not otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

C. Wireway Covers: Hinged type with screws to close.

D. Finish: ANSI 49 gray powder finish inside and out over phosphatized surfaces. Provide NEMA rating appropriate for use intended.

2.4 OUTLET AND DEVICE BOXES

A. Boxes shall not contain concentric knockouts.

B. Sheet Metal Boxes: NEMA OS1 and UL 514A.

C. Cast Metal Boxes: NEMA FB1, type FD, cast ferro-alloy box with gasketed cover.

D. Exposed Outlet Boxes: UL 514A steel, malleable iron or cast iron boxes with threaded conduit entry for surface-mounting in areas having exposed conduit systems.

E. Flush Outlet Boxes: UL 514A hot-dip galvanized steel, square or rectangular, 2 1/8 inches deep by 4 inches square, with extension ring where necessary.

F. Boxes for Lighting Fixtures: Flush-mounted or in concealed areas to be octagonal, 4 inches by 2 1/8 inches deep, galvanized steel, with fixture stud supports and attachments to properly support ceiling and bracket type lighting fixtures. Surface-mounted to be malleable or cast iron boxes with threaded conduit hub.

G. Fittings: UL 514B.

H. Boxes in concrete shall be cast metal or in exterior locations.

2.5 PULL AND JUNCTION BOXES

A. Small Sheet Metal Boxes: NEMA OS1 and UL 514A.

B. Cast Metal Boxes: Threaded-hub type conforming to UL 514A and UL 514B. Galvanized steel conforming to UL 514A and UL 514B.

2.6 CABINETS AND ENCLOSURES

A. Hinged Cover Enclosures: NEMA 250, steel enclosure with continuous hinge cover and handle. Finish inside and out with manufacturer's standard enamel.

B. Cabinets: NEMA 250, type 1 code gauge galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard ANSI 49 gray powder finish. Hinged door in front cover with flush latch and concealed hinge. Hinged doors for large enclosures (particularly panelboards) shall have a minimum of a double latch or 4 screws for ease of opening and closing doors. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment. Cabinets shall be constructed with interior dimensions not less than those indicated on the drawings. Provide 5/8-inch plywood backboard unless otherwise indicated. Key latch to match panelboards. Provide two keys with each cabinet unless otherwise notified.

C. Safety: UL 50.

D. Control Enclosures: NNEMA ICS-6.

E. Telephone and Signal Cabinets: Construct in accordance with NFPA 70 Article 312.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive raceways, boxes, enclosures and cabinets for compliance with installation tolerances and other conditions affecting performance of the raceway system. Do not proceed with installation until unsatisfactory conditions have been corrected. Examine raceways prior to installation. No crushed or deformed raceways shall be installed.

3.2 WIRING METHODS

A. Outdoors: Use the following wiring methods:

1. Exposed: PVC Coated RMC.
2. Concealed: RMC.
3. Underground, Single Run: Concrete-encased PVC 40, except last 10’ entering a handhole or building shall be concrete-encased RMC and fittings, painted with asphaltic.
4. Underground, Grouped: Concrete-encased PVC 40, except last 10’ entering a handhole or building shall be concrete-encased RMC and fittings, painted with asphaltic.
5. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): LFMC.
6. Boxes, Enclosures: NEMA Type 4X.
7. Disconnects (fused or non-fused): NEMA 4X Stainless Steel

B. Indoors: Use the following wiring methods:

1. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): LFMC.
2. Damp or Wet Locations: RMC.
3. Exposed: RMC. Rigid metal conduit shall be used up to a height of 8 feet above finished floor. EMT may be used exposed where greater than 8’-0” AFF or in electrical chases.
4. Concealed: EMT, RMC (EMT may be used for lighting, receptacles, communications, fire alarm, security and environmental conditions in concealed locations indoors).
5. Boxes and Enclosures: NEMA Type 1, except in damp or wet locations use NEMA Type 4, stainless steel.
6. Conduit Use: Install RMC for all branch circuit panelboard feeders, distribution panel board feeders, transformer feeders, and distribution switchboard feeders. Install EMT for communication, lighting and power branch circuits. USE RMC for all exposed conduit systems within electrical and mechanical equipment rooms and electrical closets from floor level to a height of 8 feet above finished floor. Conduit for communications, lighting and power branch circuits may be transitioned to EMT above 8 feet above finished floor.

3.3 INSTALLATION

A. Products shall be installed in accordance with FAA 1217f and FAA STD 019e. Install raceways, boxes, enclosures and cabinets as indicated, according to manufacturer's written instructions. Minimum size raceway shall be 3/4-inch, unless otherwise noted. Conduit for telephone and signal systems shall be as follows:

1. 3/4-inch conduit may be used for lengths not exceeding 100 feet.
2. 1-inch conduit shall be used for lengths exceeding 100 feet.
3. No run shall contain more than two 90 degree bends, or the equivalent.
4. Provide pull and junction boxes as required to meet the above criteria.

B. Conduit/Raceway Installation: Conceal conduit including EMT, unless otherwise indicated, within finished walls, ceilings and floors. Raceways shall not be attached to the ceiling suspension system. Raceways shall not be attached to or supported by roof decks. Do not anchor or strap raceways to wall furring channels or to other raceways. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Do not install raceways near uninsulated high temperature services without prior approval of the Contracting Officer's Technical Representative. Install horizontal raceway runs above water and steam piping.

1. Install raceways level and square and at proper elevations. Provide adequate headroom. Conduits and raceways shall run parallel or perpendicular to building structural members.
2. Install conduit to drain moisture to nearest outlet or pull box.
3. Inside radii of bends in conduits shall not be less than 6 times the nominal diameter.
4. No run shall contain more than four 90 degree bends, or the equivalent between conduit terminations.
5. Signal raceway 2 inches and smaller shall have no run of 1/2-inch or 3/4-inch exceed 50 feet; or 100 feet for 1-inch or larger and a maximum of two 90 degree bends, or the equivalent. Install pull boxes or junction boxes where necessary to comply with these requirements.
6. Provide conduit bodies, pull and junction boxes required to meet the bends criteria.

7. Provide a pull box for critical power circuits for three 90 degree bends. Threaded conduit bodies shall be used for all critical power circuits.
8. Install a pull wire in all empty tubing and conduit systems. Pull wire shall be No. 14 AWG zinc-coated steel or plastic with a minimum 200 pound tensile strength. Provide 10 inches of slack at each end of the pull wire.
9. Complete raceway installation before starting conductor installation. Raceways shall be fished and swabbed before conductors are pulled.

C. Support of Raceways: Support raceways and boxes as specified in Section 26 05 29, “Hangers and Supports for Electrical Systems.” Boxes for fixtures on suspended ceilings shall be supported independently of the ceiling supports. Boxes shall not be supported from sheet metal roof decks.

D. Raceway Protection: Use temporary closures to prevent foreign matter from entering raceway. Prevent the lodgment of plaster, dirt or trash in raceways, boxes, fittings, and equipment during construction. Clogged raceways shall be entirely freed of obstructions or shall be replaced. Clean each conduit run before pulling in conductors. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above finished slab.

E. Bends and Offsets: Make bends and offsets so the inside diameter is not reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel. IMC bends shall be fabricated with tooling specifically designed for bending IMC. Signal conduit that is 1-inch and larger shall have a minimum inside radii 12 times the nominal conduit diameter. No run shall contain more than four 90 degree bens or the equivalent. Provide pull and junction boxes required to meet the bends criteria. For critical power conduits, only conduit bodies are allowed.

F. Raceway Fittings: Use raceway fittings compatible with raceway and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, except as otherwise indicated. Screw-type fitting are not acceptable in any application.

G. Concealed Raceways: Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions, except as otherwise indicated.

H. Raceways in Damp, Concealed or Underground Locations: Raceways or sections of raceways which pass through to damp, concealed, or underground locations shall be of a type allowed for such locations by NFPA 70 and shall extend a minimum of 12 inches beyond the damp, concealed, or underground area.

I. Floor and Wall Penetrations: Penetrations through walls or floors shall be sealed to prevent moisture and rodent entry and to deter air transfer. Seal penetrations of walls, which separate individually temperature or humidity controlled areas to prevent air circulation.

J. Installation at Structural Members: Install raceways parallel to or at right angles to nearby surfaces of structural members and follow the surface contours as much as practical. Run parallel or banked raceways together, on common supports where practical. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways.

K. Joining of Raceway Fittings: Join raceway fittings designed and approved for the purpose and make joints tight. Use bonding locknuts and bushings at connections subject to vibration. Use bonding jumpers where joints cannot be made tight. Use insulating throat connectors for all conduits to protect conductors where a grounding bushing is not required. Provide expansion fittings for all raceways passing through the building expansion joints and for conduit runs longer than 300 feet.

L. Terminating: Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

M. Pull Wires: Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200 pound tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

N. Stub-Up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this Contract, install screwdriver-operated threaded plugs flush with floor.

O. Flexible Connections: Use maximum of 6 feet of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Provide #6 AWG stranded insulated green copper bonding jumper terminated on an approved grounding fitting at each end of the flex metal conduit.

P. Metal Conduits: Metal conduits shall be mechanically and electrically continuous between outlets, junction boxes and pull boxes, panels, cabinets and similar equipment. Conduits shall enter and be secured to enclosures so that each system is electrically continuous throughout.

Q. Enclosures and Cabinets: Install hinged cover enclosures and cabinets plumb. Support at each corner.

R. Grounding Connections: Provide grounding connections for raceways, boxes, and components. Sheet metal or self-tapping screws shall not be used for grounding and bonding connections. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL 486A. Provide ground bushings for all feeder conduits at switchgear, switchboards, panelboards, transformers, pull boxes and all other termination points. Where knockouts are used, provide double locknuts, one on each side with a grounding bushing or grounding locknut used on the inside (use grounding bushings on conduit 1-inch and larger).

S. Field-Cut Conduit: Where conduit has to be cut in the field, it shall be cut square. The cut ends of the field-cut conduit shall be reamed to remove burs and sharp edges.

T. Field-Threaded Conduit: Where threads have to be cut on conduit, the threads shall have the same effective length and shall have the same thread dimensions and taper as specified for factory cut threads on conduit.

U. Boxes: Shall be provided in the wiring or raceway system for pulling wires, making connections and mounting devices or fixtures. Each box shall have the volume required by NFPA 70 for the number and size of conductors in the box. Label all junction/pull boxes with panelboard name and circuit number with permanent marker.

V. Outlet Boxes: Each outlet box shall have a machine screw which fits into a tapped hole in the box for the ground connection. Attach boxes to ceilings which are not suspended in at least two places. Distribute lighting fixture load over the ceiling boxes.

W. Concealed Wiring: Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. The front edge of the box shall be flush or recessed not more than 1/4-inch from the finished wall surface (whether the finished surface is drywall, or drywall and a sound absorbing material).

X. Boxes in Masonry Block or Tile Walls: Shall be square-cornered title-type, or standard boxes shall have square-cornered tile-type covers.

Y. Wet Locations: Cast metal boxes installed in wet locations, in concrete and boxes installed flush with exterior surfaces shall be gasketed.

Z. Mounting: Install switch box on the strike side of the door at mounting height of 48 inches. Unless otherwise indicated, mounting height of receptacle boxes shall be 18 inches. Height of wall-mounted outlet box is defined as the height from finished floor to horizontal centerline of the cover plate. Where outlets are indicated adjacent to each other, mount outlets in a symmetrical pattern with tops at the same elevation. Where outlets are indicated adjacent, but with different mounting heights, line up outlets on a vertical line. Verify the final location of each outlet before installation. Remove and relocate outlet boxes placed in an unacceptable position. At fire-rated partitions, offset boxes to prevent back-to-back installation.

AA. Box Openings: Provide only the openings necessary to accommodate the conduits at the individual location. When this is not practical, plug unused openings.

BB. Junction, Transition, and Pull Boxes: Install junction, transition, and pull boxes so that covers are not readily accessible. Boxes in concealed areas of ceiling or wall shall be accessible through removable panels. Locate pull boxes to permit easy pulling of wire or cables. Securely attach boxes to structural and framing members using compatible fasteners of adequate size. Bolt wall-mounted boxes to steel profiles fastened to the wall.

CC. Grounding: Provide each box with a green machine screw. Screw into tapped hole in the box for ground wire or lug connection.

DD. RMC or IMC below Slab on Grade or Underground: The conduit shall conform to SSPC PS-10.01 Or shall be field wrapped with 0.01-inch thick pipe wrapping plastic tape applied with 50 percent overlay.

EE. EMT Entering Enclosure without Threaded Hubs: Provide a connector with threads and cast or machined locknut. The connector body and locknut shall be installed so that firm contact is made on each side of the enclosure.

3.4 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at substantial completion. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer. Repair damage to PVC or paint finishes with matching touch- up coating recommended by the manufacturer. Cap stubbed up raceways, including raceways in cabinets, immediately upon installation. The use of paper or rag wads is not acceptable.

B. Galvanic Corrosion Protection: Avoid dissimilar metals in contact anywhere in conduit runs. Where contact cannot be avoided at conduit terminations, treat the connection with joint compound that eliminates galvanic corrosion. Where dissimilar metals are in contact, such as at aluminum cable tray or enclosures and steel supports, separate contact surfaces by using gaskets, non-absorptive tape or coating to prevent galvanic corrosion.

3.5 CLEANING

A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 26 05 33

SECTION 26 05 48 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

B. ASTM International:

1.	ASTM A 1011	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
2.	ASTM A 325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 Ksi Minimum Tensile Strength.
3.	ASTM A 36	Standard Specification for Carbon Structural Steel.
4.	ASTM A 575	Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
5.	ASTM A 576	Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
6.	ASTM B 603	Standard Specification for Drawn or Roller Iron-Chromium-Aluminum Alloys for Electrical Heating Elements.

C. International Code Council:

1. IBC, International Building Code.

D. Manufacturers standardization Society (MSS):

1.	MSS SP-69	Pipe Hangers and Supports - Selection and Application.

E. U.S. Army Corps of Engineers (USACE)

1.	TI 809-B4	Seismic Design for Buildings

1.2 SUMMARY

A. This Section includes seismic restraints and other earthquake damage reduction measures for electrical components.

1.3 DEFINITIONS

A. The IBC: International Building Code.

B. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt, or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.

C. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

D. Positive Attachment: A cast-in anchor, a drill-in wedge anchor, a double-sides beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single-sided "C" type beam clamps for support rods of overhead equipment are not acceptable on this project as seismic anchor points.

E. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe or duct.

F. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe or duct.

G. Failure: For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8-inch and/or horizontal permanent deformation greater than 1/4-inch.

1.4 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, “Submittal Procedures:”

1. Shop Drawings: For anchorage and bracing not defined see details and charts on the drawings. Indicate materials and show designs and calculations signed and sealed by a professional engineer.
2. Details: Detail fabrication and arrangement. Detail attachment of restraints to both structural and restrained items. Show attachment locations, methods and spacing, identifying components and list their strengths. Indicate direction and value of forces transmitted to the structure during seismic events.
3. Pre-approval and Evaluation Documentation: By ICBO Evaluation Service, or an agency approved by authorities having jurisdiction, showing maximum ratings of restraints and the basis for approval (tests or calculations).
4. Coordination Drawings: Plans and sections drawn to scale and coordinating seismic bracing for electrical components with other systems and equipment, including other seismic restraints, in the vicinity. Provide coordination drawings in accordance with SECTION 01 40 10 - CONTRACTOR-PREPARED COORDINATION DRAWINGS
5. Product Data: Illustrate and indicate types, styles, materials, strength, fastening provisions, and finish for each type and size of seismic restraint component used.
6. Anchor Bolts and Studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by ICBO Evaluation Service, or an agency approved by authorities having jurisdiction.

7. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
8. Material Test Reports: From a qualified testing agency indicating and interpreting test results of seismic control devices for compliance with requirement indicated.
9. Product Certificates: Signed by manufacturers of seismic restraints certifying that products furnished comply with requirements.
10. Qualification Data: For firms and persons specified in "Quality Assurance" paragraph.

1.5 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where project is located and who is experienced in providing seismic engineering services, including the design of seismic restraints, that are similar to those indicated for this project.

B. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated.

1.6 PROJECT CONDITIONS

A. Facility is an essential air traffic control facility. Design equipment, equipment bracing, and anchorage in accordance with the IBC. The requirements for seismic protection measures to be applied to electrical equipment and systems specified herein are in addition to any other items called for in other Sections of the Specification. Provide seismic bracing for equipment and systems within the project area. Seismic forces shall be calculated by a qualified licensed professional engineer per IBC, ASCE 7, Section 12.13.3.

1.7 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural system and architectural features, and with mechanical, fire protection, electrical and other building features in the vicinity. Coordinate concrete bases with building structural system.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoor and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.2 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to authorities having jurisdiction.

B. Structural Safety Factor: Strength in tension and shear of components used shall be at least 2 times the maximum seismic forces to which they will be subjected.

C. Concrete and Masonry Anchor Bolts and Studs: Steel expansion wedge type.

D. Concrete Inserts: Steel channel type.

E. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

F. Welding Lugs: Comply with MSS SP-69, Type 57.

G. Beam clamps for Steel Beams and Joists: Double-sided. Single-sided type is not acceptable.

H. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings and matched to the type and size of anchor bolts and studs used.

I. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings and matched to the type and size of attachment devices used.

2.3 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1 5/8-inch by 1 5/8-inch cross-section, formed from 0.1046-inch thick steel, with 9/16-inch by 7/8-inch slots at a maximum of 2 inches on center in webs, and flange edges turned toward web.

B. Materials for Channel: ASTM A 1011, GR 33.

C. Materials for Fittings and Accessories: ASTM A 575, ASTM A 576, or ASTM A 36.

D. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.

E. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

F. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

G. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets and bolts designed for cable service. Arrange units for attachment to the braced component at one end and to the structure at the other end. For wire rope cable comply with ASTM B 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

H. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with Section 23 05 48, “Vibration and Seismic Controls for HVAC Piping and Equipment.”

3.2 INSTALLATION

A. Install seismic restraints according to applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent requirements are indicated.

3.3 STRUCTURAL ATTACHMENTS

A. Attachments to New Concrete: Bolt to channel-type concrete inserts or use expansion anchors.

B. Attachments to Existing Concrete: Use expansion anchors.

C. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.

D. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.

E. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.

F. Attachments to Wood Structural Members: Install bolts through members.

G. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

3.4 ELECTRICAL EQUIPMENT ANCHORAGE

A. Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element. Anchor panelboards, motor controllers, transformers, fused power circuit devices, transfer switches, communication system components, and electrical signal processing, control and distribution units as follows:

1. Size concrete bases so expansion anchors will be a minimum if 10 bolt diameters from the edge of the concrete base.
2. For concrete bases for floor-mount equipment use female expansion anchors and install studs and nuts after equipment is positioned.
3. Bushings for floor-mounted equipment anchors to be installed to allow for resilient media between anchor bolt or stud and mounting hole in concrete.
4. Anchor bolt bushing assemblies for wall-mounted equipment to be installed to allow for resilient media where equipment or equipment-mounting channels are attached to wall.
5. Torque bolts and nuts on studs to value recommended by equipment manufacturer.

3.5 SEISMIC BRACING INSTALLATION

A. Install bracing according to spacing and strengths indicated by approved analysis.

B. Expansion and Contraction: Install to allow for thermal movement of braced components.

C. Cable Braces: Install with maximum cable slack recommended by manufacturer.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists or at concrete members.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Make flexible connections in raceways, cables, wireways, and cable trays where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

3.7 FIELD QUALITY CONTROL

A. Contractor shall submit manufacturer test data for each device that requires pull-out resistance.

END OF SECTION 26 05 48

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

1. This Section included identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components, including but not limited to buried electrical line warnings; identification labeling for raceways, cables, and conductors; operational instruction signs; warning and caution signs; and equipment labels and signs.

1.2 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

B. American National Standards Institute (ANSI)

1. ANSI A13.1 — Scheme for the Identification of Piping Systems.

C. FAA Specifications and Standards

1. FAA 1217f — Electrical Work, Interior.

D. National Fire Protection Association (NFPA)

1. NFPA — 70 National Electrical Codes.

1.3 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, “Submittal Procedures.”

B. Product Data: For each type of product specified.

C. Schedule of Identification Nomenclature: Provide a schedule of identification nomenclature to be used for identification signs and labels.

D. Labels and Signs: Samples for each color, lettering style and other graphic representation required for identification materials.

E. Operation and Maintenance Data: Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “Operation and Maintenance Data.”

1.4 QUALITY ASSURANCE

A. Components and installation shall comply with NFPA 70. Comply with requirements of ANSI A13.1 with regard to type and size of lettering for raceway and cable labels.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate installing electrical identification after completing of finishing where identification is applied to field-finished surfaces. Coordinate installing electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials procured and installed in this Section, as well as identification and nameplates shall be in accordance with FAA 1217f.

2.2 RACEWAY AND CABLE LABELS

A. Manufacturer's Standard Products:

1. Where more than one type is listed for a specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.

B. Size: Conform to ANSI A13.1 for minimum size of letters for legend and minimum length of color field for each raceway or cable size.

1. Color: Black legend on orange field.
2. Legend: Indicates voltage and service.

C. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl. Legend is laminated with a clear, weather- and chemical-resistant coating.

D. Pre-tensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic bands sized to suit the diameter of the line it identifies and arranged to stay in place by pre-tensioned gripping action when placed in position.

E. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

F. Underground Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape not less than 6 inches wide by 4 mils thick, compounded for permanent direct-burial service, and embedded continuous metallic strip or core.

G. Printed Legend: Indicates type of underground line.

H. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

I. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.

J. Brass Tags: Metal tags with stamped legend, punched for fastener, 2 inches by 2 inches by 0.05-inch thick.

2.3 ENGRAVED NAMEPLATES AND SIGNS

A. Manufacturer's Standard Products: Where more than one type is listed for a specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and this Specification.

B. Engraving Stock: Melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches or 8 inches in length; 1/8-inch thick for larger sizes:

1. Engraved Legend: White letters on black face.
2. Punched for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend and size as indicated or as otherwise required for the application. 1/4-inch grommets in corners for mounting.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, non-fading, preprinted, cellulose acetate butyrate signs with 0.0396-inch galvanized steel backing, with colors, legend and size appropriate to the application. 1/4-inch grommets in corners for mounting.

E. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat and lock washers.

2.4 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, type 6/6 nylon cable ties with 3/16-inch minimum width; 50 lb minimum tensile strength; minus 40 to plus 185 degree F temperature range; and color as indicated where used for color-coding.

B. Paint: Alkyd-urethane enamel over primer as recommended by enamel manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install identification devices according to manufacturer's written instructions. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations used in the contract documents or required by codes and standards. Use consistent designations throughout the project.

C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

D. Self-Adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.

E. Painted Identification: Install painted identification as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime surfaces. For galvanized metal use single-component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units use heavy-duty, acrylic-resin block filler. For concrete surfaces use clear, alkali-resistant, alkyd binder-type sealer.
3. Apply one intermediate and one finish coat of silicone alkyd enamel.
4. Apply primer and finish materials according to manufacturer's instructions.

F. Raceway Identification: Identify raceways with color banding and lettering appropriately sized for conduit. Band exposed and accessible raceways of the systems listed below for identification:

1. Bands: Pre-tensioned, snaparound, colored plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of 2-color markings in contact, side-by-side.
2. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25 feet in congested areas.
3. Colors: As follows:

   a. Fire alarm system – red.
   b. Fire suppression supervisory and control system - yellow.
   c. Security system - orange, no lettering.
   d. Mechanical and electrical supervisory direct digital control system - blue.
   e. Telecommunications system - green

G. Circuit Box Identification Labels: Install circuit identification labels on boxes. Label externally as follows:

1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover, as well as "permanent magic marker" on inside cover.
2. Concealed Boxes: Plasticized card stock tags, as well as "permanent magic marker" on inside cover.
3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
4. Underground Electrical Line Paths: During trench backfilling, for exterior underground power, control, signal and communications lines, install continuous underground warning tape located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope, do not exceed an overall width of 16 inches, use a single line marker. Install warning tape for underground wiring, both direct buried and in raceway.

5. Color-Code Conductors: The following field-applied color-coding methods may be used in lieu of factory-coded wire listed in Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables", for sizes larger than No. 4 AWG. Contractor shall demonstrate non-availability of factory-colored wire before using this application:

    a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. apply the last 2 turns of tape with no tension to prevent possible unwinding. Use 1-inch wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings.
    b. Where conductors are color-coded by this method, they shall be color-coded in accessible raceways, panelboards, outlets, and switches, as well as at all terminations. Conductors in accessible raceways shall be color-coded so that by removing or opening any cover, the coding will be visible.
    c. Phase, ground, and neutral conductors shall be color-coded in accordance with Section 26 05 19, "LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES."
    d. Green insulated conductors shall not be re-identified for purposes other than grounding.
    e. White or neutral gray conductors shall not be re-identified for purposes other than grounded neutrals.

H. Power Circuit Identification: Use metal tags for cables, power feeders in pull boxes, junction boxes, handholes, and switchboard rooms:

1. Legend: 1/4-inch steel letter and number stamping or embossing with legend corresponding to indicated circuit designations and conductor size.
2. Fasten tags with nylon cable ties; fasten bands using integral ears.

I. Conductor Identification: Apply identification to conductors as follows:

1. Conduits and Conductors to be extended in the Future: Indicate source and circuit numbers.
2. Multiple Power or Lighting Circuits in Same Enclosure: Identify each conductor with source, voltage, circuit number and phase. Use color-coding for voltage and phase indication of secondary circuit.
3. Multiple Control and Communication Circuits in Same Enclosure: Identify each conductor by its system and circuit designation at enclosure and terminations. Use a consistent system of tags, color-coding or cable marking tape.
4. Warning, Caution, and Instruction Signs: Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
5. Emergency-Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer and other emergency operations.

6. Equipment Identification: Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication, signal and alarm systems, unless units are specified with their own self-explanatory identification. Provide equipment, required under Division 26 with nameplate indicating equipment name, system voltage(s) and phase. Except as otherwise indicated, provide a single line of text with 1/2-inch high lettering on 1 1/2-inch high label; where 2 lines of text are required, use larger 2-inch high label. Use white lettering on black field. Apply labels for each unit of the following categories of equipment.

   a. Panelboards, electrical cabinets and enclosures.
   b. Access doors and panels for concealed electrical items.
   c. Motor starters.
   d. Power disconnect switches.
   e. Control devices.

J. Conduit Labeling: Label conduit at each end and at pull boxes with characters a minimum 1/4-inch high. Each label shall note internal conductor type and other terminal end. Attach labels around conduit for permanent mounting.

K. Other Components Labeling: Apply identification labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, and similar items for power distribution control components above, except panelboards, and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

L. Receptacles: Provide self-adhesive plastic with panel name and circuit for each receptacle, located on coverplate.

END OF SECTION 26 05 53

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes various types of receptacles, connectors, multi-outlet assemblies, wall switches, and finish plates.

B. This Section includes requirements for the furnishing and installing of fire rated wiring devices. Furnish and install all fire rated wiring devices and associated hardware as shown on the Contract Drawings and as hereinafter specified. All devices shall be heavy-duty specification grade with an intumescent insert material allowing for 0 to 100-percent visual fill of conductors. The same manufacturer shall supply all furnished fire rated devices and associated hardware.

1.2 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

1. Federal Standards (FS)

   a. FS WC-596 — General and Associated Detailed Specifications: Connector, Plug Receptacle, and Cable Outlet, Electrical Power

2. Institute of Electrical and Electronics Engineers (IEEE)

   a. IEEE C62.41 — Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

3. National Electrical Manufacturers Association (NEMA)

   a. NEMA WD-1 — General Requirements for Wiring Devices

4. National Fire Protection Association (NFPA)

   a. NFPA 70 — National Electrical Code

5. Occupational Safety and Health Administration (OSHA)

   a. 29 CFR 1910.7 — Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

6. Underwriters Laboratories (UL)

a.	UL 1472	Solid-State Dimming Controls
b.	UL 20	General Use Snap Switches
c.	UL 498	Electrical Attachment Plugs and Receptacles
d.	UL 943	Ground Fault Circuit Interrupters

1.3 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, "SUBMITTAL PROCEDURES."

B. Product data for each product specified.

C. Operations and Maintenance Data: Prepare and distribute operations and maintenance data as specified in Section 01 78 23, "OPERATION AND MAINTENANCE DATA."

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70, for devices and installation.

B. Listed and Labeled: Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed. The Terms "listed" and "labeled" are as defined in NFPA 70, Article 100.

C. Listing and Labeling Agency Qualifications: Listing and Labeling Agency must be a NRTL as defined in 29 CFR 1910.7.

D. Fire-rated devices shall bear the UL Classification marking. Devices shall be tested in accordance with ASTM E 814 (ANSI/UL 1479).

1.5 COORDINATION

A. Wiring Devices for Government Furnished Equipment (GFE): Match devices to plug connectors for GFE. Device plates shall be stainless steel, brushed finish. Convenience receptacles shall be brown; computer receptacles shall be ivory; receptacles for essential circuits shall be red; and receptacles for critical circuits shall be orange.

B. Cord and Plug Sets: Match cord and plug sets to equipment requirements.

PART 2 - PRODUCTS

2.1 WIRING DEVICES

A. Comply with NEMA WD-1 and UL approved specification grade.

B. Enclosures: Interior shall be NEMA 1 Equivalent, except as otherwise indicated. Exterior receptacles shall be mounted in waterproof cast outlet boxes with waterproof covers.

C. Receptacles: All receptacles shall be specification grade in accordance with NEMA WD-1. Wiring terminals shall be of the screw-type. Receptacles with push-in connections or a combination of screw-type and push-in connectors are not acceptable.

1. Straight-Blade: Except as otherwise indicated, comply with FS WC-596 and Specification Grade of UL 498. Provide NRTL labeling of devices to verify compliance.

a. Rated 20 amperes at 125 and 250 volts AC. 125 volt AC receptacles shall have NEMA WD-1 type 5-20R configuration.
b. Specification Grade with body of fire resistant non-absorptive thermoplastic material.
c. 2-pole, 3-wire grounding type with polarized parallel slots.
d. Side wired with two screws for each terminal and one screw for grounding.
e. Grounding pole connected to mounting yoke.
f. Outlet grounding shall be accomplished by the installation of a #12 AWG green insulated equipment ground conductor from the ground bus in the panel board to the receptacle grounding screw of the receptacle. A green pigtail #12 AWG conductor shall also be installed from the receptacle grounding screw to the grounding lug on the outlet box.

2. Special Receptacles: NEMA as indicated on drawings.

D. Weatherproof Receptacles: Provide in cast metal box with gasketed, weatherproof, cast-metal cover plate and gasketed cap over each receptacle opening that can be closed while a device plug is inserted. Provide caps with a spring-hinged flap. Receptacle shall be UL-listed for use in "wet locations".

E. Fire-Rated Wiring Devices:

1. Cables passing through fire-rated floors or walls shall pass through fire-rated wiring devices which contain an intumescent insert material that adjusts automatically to cable additions or subtractions.
2. The device (per code requirements) shall include both internal and external firestopping.
3. Cables penetrating through fire-rated floors or walls shall utilize fire-rated pathway devices capable of providing an F rating equal to the rating of the barrier in which the device is installed.
4. The device shall be tested for smoke leakage (L rating) and shall not require the use of any optional sealing materials to achieve the published rating.
5. The device shall utilize a fire and smoke sealing system that automatically adjusts to the addition or removal of cables.
6. Wiring devices shall be capable of allowing a 0 to 100-percent visual fill of cables.
7. Wire devices shall be of a sufficient size to accommodate the quantity and size of electrical wires and data cables required and shall be suitable for use with new or existing cable installations.
8. The installed device (in normal use) shall require no maintenance and shall accommodate future cable changes without mechanical adjustment and/or removal or replacement of protective materials.
9. Wire devices to be provided with steel wall plates allowing for single or multiple devices to be ganged together.

10. The device shall be modular and shall provide mechanical installation options for common wall and floor constructions as well as common construction conditions including over-sized or damaged openings or existing sleeves.
11. Acceptable manufacturers shall be EZ-Path Fire-Rated Pathway or approved equal.

F. Device Plates: Single and combination types that mate and match with corresponding wiring devices. Color and finish as indicated. Features include the following:

1. Plate-Securing Screws: Metal with heads colored to match plate finish.

    a. Material for Finished Spaces: Brushed stainless steel with beveled edge.
    b. Material for Unfinished Spaces: Raised type galvanized steel.

2. Wet Locations: Plates installed in wet locations shall be gasketed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies plumb and secure, with alignment tolerances of 1/16-inch. Install wall plates when painting is complete. Protect devices and assemblies during painting. Receptacles shall be installed 18 inches above finished floor, unless noted otherwise. Wall switches shall be installed 48 inches above finished floor, unless noted otherwise.

B. Arrangement of Devices: Except as otherwise indicated, mount flush with long dimension vertical, and grounding terminal of receptacles at bottom. Group adjacent switches under single, multi-gang wall plates. Install switches up or to left for ON position. Mount receptacles in uniform position and same polarity.

C. Device Plates: Plates shall be installed with all four edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plates installed in wet locations shall be gasketed. Use of sectional type device plates shall not be permitted.

D. Fire-Rated Wiring Devices:

1. Install the devices in strict accordance with the approved shop drawings and the equipment manufacturer’s recommendations.
2. Apply the factory supplied gasketing material prior to the installation of the wall plates.

3.2 IDENTIFICATION

A. Comply with Section 26 05 53, “IDENTIFICATION FOR ELECTRICAL SYSTEMS.” For receptacles identify the panelboard and circuit and number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on both faces of plate and durable wire markers or tags within outlet boxes.

3.3 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 26 27 26

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SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes individually mounted switches and circuit breakers used for feeder and equipment disconnect switches; feeder overcurrent protection; motor disconnect switches; and enclosed circuit breakers.

1.2 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

1. FAA Specifications and Standards

a.	FAA Order 6950.2	Electrical Power Policy Implementation at National Airspace System Facilities.
b.	FAA Order 6950.27	Short Circuit Analysis and Protective Device Coordination Study.
c.	FAA Standard 1217f	Electrical Work Interior

2. Federal Standards (FS)

a.	FS WC-375	Circuit Breakers, Molded Case, Branch Circuit and Service

3. International Electrical Testing Association (NETA)

a.	NETA ATS	Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems

4. Manufacturers Association (NEMA)

a.	NEMA AB1	Molded Case Circuit Breakers and Molded Case Switches
b.	NEMA KS1	Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

5. National Fire Protection Association (NFPA)

a.	NFPA 70	National Electrical Code

6. Occupational Safety and Health Administration (OSHA)

   a. 29 CFR 1910.7 — Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

7. Underwriters Laboratories (UL)

   a. UL 486A — Wire Connectors and Soldering Lugs for Use with Copper Conductors

1.3 SUBMITTALS

The following shall be submitted in accordance with 013300 SUBMITTAL PROCEDURES:

A. Product Data

   1. Switches
   2. Circuit Breakers
   3. Other specified accessories
   4. Include descriptive data and time-current curves; let-through current curves for circuit breakers with current-limiting characteristics. Coordinate charts and tables and related data.

B. Test Reports

   1. Field Testing
   2. Field test reports indicating and interpreting test results.

C. Substitutions: Contractor shall submit in accordance with Section 01 25 00 “SUBSTITUTION PROECDURES”

D. Certificates

   1. Firms and Persons Qualifications
   2. Qualification data for firms and persons specified in the "QUALITY ASSURANCE" article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Operations and Maintenance Data

   1. Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “OPERATION AND MAINTENANCE DATA.”

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 for components and installation.

B. Testing Agency Qualifications: Independent testing agency shall meet 29 CFR 1910.7 criteria for accreditation of testing laboratories, or shall be a full-member company of the International Electrical Testing Association (NETA).

C. Testing Agency's Field Supervisor: Person currently certified by NETA or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in PART 3.

D. Source Limitations: Obtain disconnect switches and circuit breakers from one source and by a single manufacturer.

E. Listed and Labeled: Provide disconnect switches and circuit breakers specified in this Section that are listed and labeled. The terms "Listed" and "Labeled" are as defined in NFPA 70, Article 100.

F. Listing and Labeling Agency Qualifications: A NRTL as defined in 29 CFR 1910.7.

G. Available Fault Current: All provided gear from this Section shall be suitable for the available fault current in the area of use.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Provide disconnect switches and breakers by Square D.

2.2 DISCONNECT SWITCHES

A. Switches shall be of heavy duty type and the voltage and current ratings indicated on the drawings, and each shall be capable of interrupting the locked rotor current of the motor for which it is to be used. The locked rotor current will be assumed to be 10 times the full rated load current. Switches shall be the quick-make, quick-break type. Except for ground lugs which shall be bonded to the housing, parts shall be mounted on insulating bases to permit replacement of any part from the front of the switch. All current carrying parts shall be of high conductivity copper unless otherwise specified, and shall be designed to carry rated current without excessive heating. Switch contacts shall be silver tungsten or plated to minimize corrosion, pitting and oxidation and to assure suitable conductivity.

B. Enclosed, Non-Fusible Switch: NEMA KS1, type heavy duty, lockable handle, with 2 padlocks.

C. Enclosures: NEMA KS1, type 1, unless otherwise specified or required to meet environmental conditions of installed location.

1. Outdoor Locations: Type 4X Stainless Steel.
2. Other Wet or Damp Indoor Locations: Type 4X Stainless Steel.

2.3 ENCLOSED CIRCUIT BREAKERS

A. Enclosed, Molded-Case Circuit Breaker: NEMA AB1, lockable handle, with 2 padlocks complying with FS WC-375.

B. Characteristics: Interrupting rating, frame size, trip rating, number of poles, and auxiliary devices as indicated. Circuit breakers shall have a quick-make and quick-break toggle mechanism, inverse-time trip characteristics and shall be trip-free on overload or short-circuit. Automatic release shall be secured by bi-metallic thermal element releasing the mechanism latch. A magnetic armature shall be provided to trip the breaker instantaneously for short-circuit currents above the overload range. Automatic tripping shall be indicated by a handle position between the manual OFF and ON positions.

C. Interchangeable Trips: Circuit breakers, 200 amperes and larger, with trip units interchangeable within frame size.

D. Field-Adjustable Trips: Circuit breakers, 400 amperes and larger, with adjustable, short-time and continuous-current settings.

E. Molded-Case Switch: Where indicated, molded-case circuit breaker without trip units.

F. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.

G. Shunt Trip: Where indicated. 120 volts, 60 Hz.

H. Accessories: As indicated.

I. Enclosure: NEMA AB1, type 1, unless otherwise specified or required to meet environmental conditions of installed location.

1. Outdoor Locations: Type 4X Stainless Steel.
2. Other Wet or Damp Indoor Locations: Type 4X Stainless Steel.

J. Motor Disconnect: Provide each motor with a disconnecting means and a manually operated switch as shown on the drawings or when required by NFPA 70.

K. Single Phase Motors: Provide a single-pole or double-pole toggle switch, rated only for AC, for motor capacities less than 30 amperes, providing that the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install disconnect switches and circuit breakers in locations as indicated, according to manufacturer's written instructions. Install disconnect switches and circuit breakers level and plumb. Install wiring between disconnect switches, circuit breakers, control and indication devices. Connect disconnect switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A. Identify each disconnect switch and circuit breaker according to requirements specified in Section 26 05 53, "Identification for Electrical Systems." Ensure NFPA 70 working space and dedicated electrical space are maintained. Do not install in a location that will violate NFPA 70.

3.2 FIELD QUALITY CONTROL

A. Testing: After installing disconnect switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Visual and Mechanical Inspection:

a. Compare nameplate data with specifications and approved shop drawings.
b. Inspect circuit breaker for correct mounting.
c. Operate circuit breaker to ensure smooth operation.
d. Inspect case for cracks or other defects.

2. Electrical Tests:

a. Perform contact-resistance tests on each breaker.
b. Perform insulation-resistance tests.
c. Perform Breaker adjustments for final settings in accordance with Government provided settings.

B. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, for disconnect switches and for molded-case circuit breakers. Certify compliance with test parameters. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.3 ADJUSTING

A. Set field-adjustable disconnect switches and circuit-breaker trip ranges as indicated.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish.

END OF SECTION 26 28 16

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SECTION 26 29 13 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

1. ASTM International (ASTM)

a.	ASTM E 699	Practice for Criteria for Evaluation of Agencies Involved in Testing Quality Assurance, and Evaluating Building Components in Accordance with Test Methods Promulgated by ASTM Committee

2. International Electrical Testing Association (NETA)

a.	NETA ATS	Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems

3. National Electrical Manufacturers Association (NEMA)

a.	NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
b.	NEMA ICS 2	Standard for Industrial Control Devices, Controllers and Assemblies

4. National Fire Protection Association (NFPA)

a.	NFPA 70	National Electrical Code

5. Occupational Safety and Health Administration (OSHA)

a.	29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

6. Underwriters Laboratories (UL)

a.	UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
b.	UL 508	Industrial Control Equipment

1.2 SUMMARY

A. This Section includes AC motor control devices rated 600 V and below that are supplied as an integral part of motor/controller packages.

1.3 DEFINITIONS

A. Motor Controller: A device that controls, protects, and energizes an electric motor, and where required, controls its speed or the torque or power delivered by it.

1.4 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, “SUBMITTAL PROCEDURES.”

B. Product Data

1. Specified Products
2. Include dimensions, ratings, and data on features and components.
3. Load-Current and Overload-Relay Heater List
4. Compile after motors have been installed and arrange to demonstrate that selection of heaters suit actual motor nameplate full-load currents.

C. Test Reports

1. Field Testing
2. Indicate and interpret test results for compliance with performance requirements.

D. Certificates

1. Qualification Data for Field Testing Agency
2. Certificates, signed by Contractor, certifying that agency complies with requirements specified in "Quality Assurance".

E. Operation and Maintenance Data

1. Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “OPERATION AND MAINTENANCE DATA.”

1.5 QUALITY ASSURANCE

A. Comply with NEMA ICS 2 and UL 508.

B. Manufacturer Qualifications: Provide controllers from manufacturers regularly engaged in the manufacture of equipment of the types and capacities indicated, with such products in satisfactory use in similar service for not less than 5 years. Manufacturer must also maintain, within 100 miles of the project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

C. Field Testing Agency Qualifications: An independent testing agency with experience and capability to satisfactorily conduct testing indicated without delaying the work. Evaluation criteria shall be according to ASTM E 699.

D. Components and Installation: NFPA 70.

E. Listed and Labeled: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in NFPA 70, Article 100.

F. Listing and Labeling Agency Qualifications: A NRTL as defined in 29 CFR 1910.7.

G. Single-Source Responsibility: Obtain similar motor-control devices from a single manufacturer.

H. Available Fault Current: All provided gear from this Section shall be suitable for the available fault current in the area of use.

1.6 COORDINATION

A. Coordinate features of controllers and control devices with pilot devices and control circuits provided in Section, “Instrumentation and Controls for HVAC.”

1.7 EXTRA MATERIALS

A. Spare Fuses and Pilot Light Indicating Lamps: Furnish 1 spare for every 5 installed units, but not less than 1 set of 3 of each kind.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. All enclosed controllers shall be of the Square D Co, with no substitutions allowed

2.2 MOTOR CONTROLLERS, GENERAL

A. Coordinate the features of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, the duty cycle of the motor, drive, and load, and the pilot device, and control circuit affecting controller functions. Provide controllers that are horsepower rated to suit the motor controlled and are of the manual reset type. Contacts shall open each ungrounded connection to the motor.

B. Overload Relays: Motors 1/8-horsepower or larger, shall have overload protection in each phase, or other equally rated method in accordance with NFPA 70. Ambient-compensated type with inverse time-current characteristic. Provide with heaters or sensors matched to nameplate full-load current of the specific motor to which connected with appropriate adjustment for duty cycle. Provide with reset button in an accessible location.

C. Enclosures: For individually mounted motor controllers and control devices, comply with NEMA 250. Provide enclosures suitable for the environmental conditions at the controller location. Provide NEMA type 1 enclosures except as otherwise indicated.

2.3 MANUAL MOTOR CONTROLLERS

A. Quick-make, quick-break molded case snap switch, with padlock facility, toggle action type indicating "ON", "OFF", and "TRIP" position with a solder ratchet type overload device and green pilot light. The thermal overload heater shall be sized according to the motor nameplate current. Controller shall be single or two pole HP rated, 115-230 volts AC where used as manual controllers for single phase motors having a current rating not in excess of 80 percent of the switch rating.

2.4 MAGNETIC MOTOR CONTROLLERS

A. Provide full-voltage, non-reversing, across-the-line, magnetic controller, horsepower rated, tested and labeled at NEMA size indicated on the drawings, with field replaceable main contacts, external manual resets, ambient compensated melting-alloy overload protection in all phases and low voltage release and the following accessories.

1. Auxiliary contacts: 2 normally open and 2 normally closed.
2. Pilot lights.
3. Start-stop pushbutton.
4. Three position "Hand-Off-Automatic" switch.

B. Reversal and Phase Loss Protection: Each 3-phase magnetic motor controller shall be provided with reversal and phase loss protection. Protective device shall cause controller to open upon loss of any one phase or reversal of phase.

C. Control Circuit: Provide control power transformer with 120 volt AC secondary holding coil with fused primary and secondary integral with controller where no other supply of 120 V control power to controller is indicated. Provide control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

D. Combination Controller: Motor circuit protector type with magnetic-only trip element calibrated to coordinate with the actual locked-rotor current of the connected motor and the controller overload relays. Provide breakers that are factory assembled with the controller, interlocked with unit cover or door, and arranged to disconnect the controller. Provide motor-circuit protectors with field-adjustable trip elements.

E. Enhanced-Protection Overload Relay: Provide overload relays with NEMA class 10 tripping characteristics where indicated. Select to protect motor against voltage unbalance and single phasing.

2.5 SOLID-STATE, VARIABLE-SPEED MOTOR CONTROLLERS

A. See Section 26 29 23, “VARIABLE FREQUENCY MOTOR CONTROLLERS.”

2.6 AUXILIARY CONTROL DEVICES

A. Factory installed in controller enclosure except as otherwise indicated. Where separately mounted, provide NEMA 1 enclosure except as otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: Provide heavy-duty type for each controller.

C. Stop and Lockout Push-Button Station: Momentary-break push-button station with a factory-applied hasp arranged so a padlock can be used to lock the push-buttoning the depressed position with the control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Elapsed Time Meters: Heavy duty with digital readout in hours.

F. Current Sensors: Rated to suit application.

G. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

H. Current-Sensing, Phase-Failure Relay: Solid-state sensing circuit with isolated contacts for hard-wired connection. Arranged to operate on phase failure, phase reversal, current unbalance from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay.

PART 3 EXECUTION

3.1 GENERAL

I. Comply with manufacturer's requirements in accordance with the direction of the Contracting Officer's Technical Representative (COTR). Ensure NFPA 70 working space and dedicated electrical space are maintained during installation of panelboards. Do not install in a location that will violate NFPA 70.

3.2 APPLICATIONS

A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions. Select horsepower rating of controllers to suit motor controlled. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.

B. Push-Button Stations: In covers of magnetic controllers for manually started motors where indicated, start contact connected in parallel with sealing auxiliary contact for low-voltage protection.

C. Hand-Off-Automatic Selector Switches: In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.

3.3 INSTALLATION

A. Install independently mounted motor-control devices according to manufacturer's written instructions.

B. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components, including the pre-testing and adjustment of solid-state controllers. Locate controllers within sight of motors controlled, unless otherwise indicated. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks conforming to Section 26 05 29, “Hangers and Support for Electrical Systems.”

3.4 IDENTIFICATION

A. Identify motor-control components and control wiring according to Section 26 05 53, “IDENTIFICATION FOR ELECTRICAL SYSTEMS.”

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Section 26 05 19, “LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.” Bundle, train, and support wiring in enclosures. Connect hand-off-automatic switch and other automatic control devices where available. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing.

B. Testing: After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

C. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Use instruments bearing records of calibration within 3 months of testing. Provide 2 weeks advance notice to the Contracting Officer's Technical Representative prior to testing and schedule test at least 1 week in advance of the test commencement. Remove and replace malfunctioning units with new units, and retest.

3.8 CLEANING

A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to demonstrate solid-state and variable-speed controllers and train Government's maintenance personnel. Conduct a minimum of 4 hours of training in operation, maintenance, and related equipment. Schedule training with the Contracting Officer's Technical Representative at least 7 days in advance.

END OF SECTION 26 29 13

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SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each VFC from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:

1. ABB Low Voltage HVAC Drives.
   a. Basis of Design: ACH 500 with by-pass mounted on the side of the VFC
2. Danfoss Inc.
   a. Approved equivalent to above
3. Yaskawa Electric America, Inc.
   a. Approved equivalent to above

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 22 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.

11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

H. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

I. Self-Protection and Reliability Features:

1. VFC shall be capable of withstanding a 10,000 volt spike, 50 joules of power, and input voltage variations from 408V up to 528V without tripping.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

J. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

L. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral Input Disconnecting Means and OCPD: UL 489, molded-case switch, with power fuse block and current-limiting fuses or UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
   1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
   2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
   3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
   4. NO alarm contact that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

   1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

   1. Power on.
   2. Run.
   3. Overvoltage.
   4. Line fault.
   5. Overcurrent.
   6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

   1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

      a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).
11. Actual Motor BHP (BHP).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

   a. A minimum of two programmable analog inputs: 0- to 10-V dc.
   b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:

   a. 0- to 10-V dc.
   b. 4- to 20-mA dc.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of 3 programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:

   a. Output frequency (Hz).
   b. Output current (load).
   c. DC-link voltage (V dc).
   d. Motor torque (percent).
   e. Motor speed (rpm).
   f. Set point frequency (Hz).
   g. Motor BHP (HP)

4. Remote Indication Interface: A minimum of 3 programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: Two.

G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Hardwired Points:

a. Monitoring: On-off status,
b. Control: On-off operation,
c. Freezestat: On-Off status
d. Smoke Detector: On-Off Status
e. RA Damper: Closed-Open Position

2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.5 FILTERING

A. VFC shall have a built- in 5% impedance reactor/filter.

2.6 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.

C. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.

D. Bypass Controller:

1. Bypass Contactor: Load-break, NEMA-rated contactor.
2. Output Isolating Contactor: Non-load-break, NEMA-rated contactor.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 50 VA.

6. Overload Relays: NEMA ICS 2.

    a. Solid-State Overload Relays:

        1) Switch or dial selectable for motor-running overload protection.
        2) Sensors in each phase.
        3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
        4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
        5) Analog communication module.

    b. NO isolated overload alarm contact.
    c. External overload, reset push button.

2.7 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications when overload protection activates.

1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.

2. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
3. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

B. Damper control circuit with end-of-travel feedback capability.

C. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

D. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

E. Remote digital operator kit.

2.8 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
1. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.9 ACCESSORIES

A. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

B. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

C. Cooling Fan and Exhaust System: For NEMA 250, Type 12; UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; 120-V ac; obtained from integral CPT. Fan replacement shall be “plug-in” replaceable with the drive running and shall not require removal of components and /or opening of the drive enclosure.

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting Controllers:

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

I. Conduits connecting to the VFC shall be metallic. Separate conduits shall be utilized for power input, power out to the motor, and controls.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:

   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges.

E. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes lightning protection for buildings and associated structures and requirements for lightning protection system components.

1.2 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

1. FAA Orders and Standards:

a.	FAA-STD-019f,	Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment

2. Lightning Protection Institute (LPI)

a.	LPI-177	Inspection Guide for LPI Certified Systems.

3. National Fire Protection Association (NFPA)

a.	NFPA 70	National Electrical Code.
b.	NFPA 780	Standard for the Installation of Lightning Protection Systems

4. Occupational Safety and Health Administration (OSHA)

a.	29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

5. Underwriters Laboratories (UL)

a.	UL 96A	Installation Requirements for Lightning Protection Systems.

1.3 SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00, “SUBMITTAL PROCEDURES.”

A. Shop Drawings: Shop Drawings detailing lightning protection system, including but not limited to air terminal locations, conductor routing and connections, bonding and grounding provisions. Include indications for use of raceway and data on how concealment requirements will be met.

B. Product Data:

1. Roof adhesive data.

C. Test Reports

1. Field Reports
2. Field inspection reports indicating compliance with specified in Section 01 78 23, “OPERATION AND MAINTENANCE DATA.”

D. Certification: Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the roofing material.

E. Qualification Data: For firms and persons specified in "QUALITY ASSURANCE" Article to demonstrate their capabilities and experience. Include data on listing or certification by nationally recognized testing laboratory (NRTL) or trade association. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

F. Operation and Maintenance Data: Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “OPERATION AND MAINTENANCE DATA.”

1.4 QUALITY ASSURANCE

A. Conform to NFPA 780. Conform to UL 96A and provide UL Master Label. Conform to the most stringent requirements of LPI certification of system, and Electrical Testing Lab (ETL) Master Label, indicating system complies with specified requirements.

B. Installer Qualifications: Engage an experienced installer who is certified by the Lightning Protection Institute as a Master Installer/Designer to install lightning protection system.

C. Listed and Labeled: Provide products specified in this Section that are listed and labeled by an organization concerned with product evaluations and that can determine compliance with appropriate standards for the current production of listed items. The terms "Listed" and "Labeled" are as defined in NFPA 70, Article 100.

D. Listing and Labeling Agency Qualifications: A NRTL as defined in 29 CFR 1910.7.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

PART 2 P R O D U C T S

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Materials: All equipment shall be UL-listed and marked in accordance with UL procedures. All equipment shall be new and of a design and construction to suit the application in accordance with UL 96A. Bronze and stainless steel may be used for some components. All lightning protection materials shall be Class II, Class I not allowed.

B. Air Terminals: Air terminals shall be solid copper, unless mounted to aluminum equipment. Copper air terminals may be nickel plated. Air terminal shall be a minimum of 12 inches in height, at least 1/2-inch diameter copper (5/8-inch diameter aluminum where required), and shall have a rounded or "bullet" point. Air terminals shall be located in accordance with the requirements of NFPA 780 and UL 96A. Air terminals shall extend at least 10 inches above the object or area they are designed to protect. Air terminals shall be placed around the perimeter of flat or gently sloping roofs at intervals not exceeding 20 feet. Wherever a risk of injury exists from falling and striking an air terminal, the tip of the air terminal shall not be less than 5 feet above the walking or working surface.

C. Main Conductors: Roof and down conductors shall be minimum class II stranded bare copper as indicated on drawing, and shall meet the requirements given in NFPA 780. Down conductors shall be routed outside of any structure, and shall not penetrate or invade that structure.

D. Secondary Conductors: Shall be a minimum class II, to provide secondary or bonding conductors as indicated on drawings. Shall be bare copper.

E. Hardware: Hardware shall meet the following requirements:

1. Fasteners: Roof and down conductors shall be fastened at intervals not exceeding 3 feet. Fasteners shall be of the same materials as the conductor base material or bracket being fastened, or other equally corrosion resistant material. Plastic, galvanized or plated materials shall not be used.
2. Fittings: Bonding devices, cable splices, and miscellaneous connectors shall be suitable for use with the installed conductor and shall be copper or bronze with exothermic weld. Bolt pressure connections of secondary conductors may be acceptable. Cast or stamped crimp type fittings shall not be used.
3. Guards: Guards shall be provided for down conductors located in or next to driveways, walkways or other areas where they may be displaced or damaged. Guards shall extend to at least six feet above, and 1 foot below grade level. Guards shall be Schedule 40 PVC. Bonding numbers shall be the same size as the down conductor. Crimp type fittings shall not be used.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Shall be in accordance with FAA-STD-019f and not violate NFPA 780.

3.2 EXAMINATION

A. Examine surfaces and conditions, with installer present, for compliance with installation tolerances and other conditions affecting performance of lightning protections system. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Installation shall conform to UL 96A. Installer shall provide an Underwriters Laboratories Master Label for the facility. Conform to the most stringent requirements when more than one standard is specified.

B. Conductor and Conduit Routing: Roof and down conductors shall maintain a horizontal or downward course. No bend in a roof or down conductor shall form an incline angle of less than 90 degrees, nor shall it have a bend radius of less than 8 inches. Conductors shall be routed external to buildings and 6 feet or more from power or signal conductors.

C. Down Conductor Terminations: Down conductors shall originate at the air terminals and shall be exothermically welded to a #4/0 AWG copper conductors prior to entering the ground. The #4/0 AWG copper conductor shall enter the ground and be welded to a ground rod that is exothermically welded to the Earth Electrode System. The ground rod shall be buried 18 inches vertically below ground level, and from 2 feet to 6 feet outside the foundation or exterior footing of the building. Provide number of down conductors indicated on drawings.

D. Down Conductor Location: Route down conductors outside of building facade. Conductors shall be in PVC conduit from ground to 6 feet above grade and exposed above 6 feet. Submit system plan which indicates exact location of down conductors, as well as intended equipment locations, to engineer for approval prior to installation. Vertical down conductors shall be tinned copper #4/0 bare.

E. Contracting Officer's Technical Representative Notification: Notify the Contracting Officer's Technical Representative at least 24 hours before concealing lightning protection system components.

F. Air Terminal Attachment: All air terminals shall be secured against overturning either by attachment to the object to be protected, or by means of braces that are permanently and rigidly attached to the building.

G. Metallic Bodies Subject to Induced Charges: Metallic bodies, on or below roof level, that are subject to induced charges from lightning include roof drains, plumbing vents, metal coping, metal flashing, gutters, downspouts, small metal wall vents, door and window frames, metal balcony railings, and generally any isolated metallic body within 6 feet of an exposed lightning protection system element. These metallic bodies shall be bonded to the lightning protection system using UL approval splices, fittings, and conductors. Conductors used for bonding these metallic bodies shall be class II secondary conductors in accordance with NFPA 780.

H. Exothermic Welds: Only exothermic welds are acceptable. Hydraulically crimped connectors are not acceptable. Dissimilar metal contact shall be avoided.

3.4 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture, unless moisture is permanently excluded from the junction of such materials. Use conductors with suitable protective coatings where conditions would cause deterioration or corrosion of conductors.

3.5 FIELD QUALITY CONTROL

A. Periodic Inspection: Provide the services of a qualified inspector to perform periodic inspections during construction and at its completion, according to LPI-177.

B. UL Inspection: Apply for inspection by UL as required for UL Master Labeling of System.

C. ETL Inspection: European Test Lab to inspect completed system for conformation with specified requirements.

3.6 TEST

A. Upon completion of installation of lighting protection system, test resistance-to-ground with resistance tester. Where tests show resistance-to-ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by treating soil proximity to ground rods with sodium chloride, copper sulfate, or magnesium. Then retest to demonstrate compliance.

END OF SECTION 26 41 13

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SECTION 26 51 19 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

1. American National Standards Institute (ANSI)

   a. ANSI C62.41 — Recommended Practice on Surge Voltage in Low-Voltage AC Power Circuits
   b. ANSI C78 — Standard for Electric Lamps

2. FAA Orders and Standards

   a. FAA-STD-1217H — Electrical Work, Interior

3. Federal Specifications (FS)

   a. FS JC-30 — Cable and Wire, Electrical

4. National Fire Protection Association (NFPA)

   a. NFPA 70 — National Electrical Code

5. Occupational Safety and Health Administration (OSHA)

   a. 29 CFR 1910.7 — Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)

6. Underwriters Laboratories (UL)

   a. UL 486A — Wire Connectors and Soldering Lugs for Use with Copper Conductors
   b. UL 8750 — LED (Light Emitting Diode) lighting technology

7. Other References

   a. IES LEM-3-13 — Upgrading Lighting Systems in Commercial and Institutional Spaces.
   b. IESNA Handbook Latest Version
   c. UFC Unified Facilities Criteria
   d. UFC 5-350-01 — Interior and Exterior Lighting Systems and Control

1.2 SUMMARY

A. This Section includes interior lighting fixtures, lamps, ballasts, emergency battery ballast, and accessories.

1.3 DEFINITIONS

A. Average Life: Time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

B. CCT: Correlated color temperature.

C. CRI: Color-rendering index.

D. Fixture: See “Luminaire”.

E. LED: Light-emitting diode.

F. LER: Luminaire efficacy rating.

G. Lumen: Measured output of lamp and luminaire, or both.

H. Luminaire: Complete lighting unit, including lamp, reflector, and housing. Includes lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply.

1.4 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00, “SUBMITTAL PROCEDURES.”

B. Product Data:

1. Lighting fixtures
2. Ballasts
3. Emergency ballasts
4. LED drivers and assemblies
5. Arrange product data for fixtures in order of fixture designation. Include data on features and accessories; outline drawings indicating dimensions and principal features of fixtures; certified results of independent laboratory tests for electrical ratings and photometric data for fixtures and lamps. Retain first paragraph below for custom lighting fixtures.

C. Substitutions: Contractor shall submit in accordance with Section 01 25 00 “SUBSTITUTION PROCEDURES.” In addition to the requirements listed in Section 01 25 00, the contractor must also submit a new lighting calculation plan showing that the submitted fixtures comply with the designed lighting requirements.

D. Operation and Maintenance Data

1. Submit in accordance with Section 01 78 23 “OPERATION AND MAINTENANCE DATA.”

1.5 QUALITY ASSURANCE

A. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL.

B. Listed and Labeled: Provide fixtures and accessory components that are listed and labeled for their indicated use and installation conditions on the project. The terms "listed" and "labeled" as defined in NFPA 70, Article 100.

C. Special Listing and Labeling: Provide fixtures for use in damp or wet locations, and recessed in combustible construction that are specifically listed and labeled for such use.

D. Listing and Labeling Agency Qualifications: A NRTL as defined in 29 CFR 1910.7.

E. Ballast Manufacturers Qualifications.

F. Coordination: Coordinate fixtures, mounting hardware, and trim with ceiling system and other items, including work of other trades, required to be mounted on ceiling or in ceiling space.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

B. Lamps: Furnish one lamp for every 10 of each type and rating installed. Furnish at least one of each type.

C. Plastic Diffusers and Lenses: Furnish one for every one hundred of each type and rating installed. Furnish at least one of each type.

D. Ballasts: Furnish one for every 20 of each type and rating installed. Furnish at least one of each type.

1.7 WARRANTY

A. General Warranty: The special warranty specified in this paragraph shall not deprive the Government of other rights the Government may have under other provisions of the contract documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the contract documents.

B. Special Warranty: Provide a written warranty signed by manufacturer and installer agreeing to replace ballasts and drivers against defects in material and workmanship for a period of 5 years from the date of substantial completion. Defective ballasts and drivers shall be replaced within the warranty period at no cost to the Government.

PART 2 - PRODUCTS

2.1 FIXTURES, GENERAL

A. Comply with the requirements specified in this Section and lighting fixture schedule indicated on the drawings. The fixtures specified in the lighting fixture schedule on the drawings establish a level of quality and appearance that any substituted fixtures must match or exceed. Substitutions for the specified fixtures will be reviewed by the Contracting Officer's Representative for compliance and approval. All lighting fixtures shall be UL-listed and shall bear the UL label.

2.2 FIXTURE COMPONENTS, GENERAL

A. Metal Parts: Free from burrs and sharp corners and edges.

B. Sheet Metal Components: Steel, except as indicated. Components are formed and supported to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

D. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metalized Film: 90 percent.

E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water white, annealed crystal glass, except as otherwise indicated.

F. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

G. Lens Thickness: 0.125-inch minimum, except where greater thickness is indicated.

H. Fixture Wiring: Thermoplastic insulated copper, rated for 600 volts, in accordance with FS JC-30 and NFPA 70.

I. Flexible metal conduit, minimum 1/2 inch nominal trade size, maximum length of 6 feet is permitted (steel only).

J. EMI and RFI Filters: Electromagnetic Interference (EMI) and Radio Frequency Interference (FRI) filters shall be Sylvania Lighting International (SLI) Cat. No. 89G635, or approved equal.

2.3 FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel supports.

B. Unless otherwise indicated on contract drawings, provide luminaire fixture support components as follow:
   1. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.
   2. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rods.
   3. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Comply with Section 3.1 of this specification document for installation and support requirements.

2.4 LAMPS

A. Furnish lamps for all fixtures in accordance with lighting fixture schedule. Conform to ANSI C78 series applicable to each type of lamp. Lamp color temperature and minimum color-rendering index (CRI) shall be 3500 K and 85 CRI, except as otherwise indicated.

2.5 FINISHES

A. Manufacturer's standard finish applied over corrosion-resistant treatment or primer, free of streaks, runs, stains, blisters, and similar defects. Remove fixtures showing evidence of corrosion during project warranty period and replace with new fixtures.

2.6 LED LUMINAIRES

A. A. General:

   1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
   2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
   3. LED drivers shall include the following features unless otherwise indicated:

      a. Minimum efficiency: 85% at full load.
      b. Minimum Operating Ambient Temperature: -20˚ C. (-4˚ F.)
      c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
      d. Integral short circuit, open circuit, and overload protection.
      e. Power Factor: ≥ 0.95.
      f. Total Harmonic Distortion: ≤ 20%.
      g. Comply with FCC requirements per CFR Title 47 Part 15 Class B:

         1) CFR Title 47 Part 15 Class B compliance to be documented via formal testing which must be developed by the LED luminaire assembly manufacturer. Testing must be performed in a FCC-certified testing lab. The project engineer of record must assure that CFR Title 47 Part 15 Class B compliance is formally stated in the luminaire (lamp, driver, enclosure assembly, as

applicable) or luminaire upgrade kit shop drawing/cut sheet/engineering data book and the lighting schedule.

2) Providing the FCC CFR Title 47 Part 15 Class B testing results/report is an A/E and/or Performance Contract provider responsibility during the schematic design phase (10%) and/or IGA (investment grade audit) phase. After the 10% submission, FAA will take the responsibility to review and approve/comment/make recommendations/reject the LED fixtures based on the FCC testing results/report review.

3) If a proposed luminaire assembly or upgrade kit is meant to serve a custom application based on a FAA request and the luminaire assembly or upgrade kit is not FCC CFR Title 47 Part 15 Class B compliant and/or the FCC testing was not performed in a FCC-certified testing lab, the project contractor must provide one sample fixture per each type to be tested for CFR Title 47 Part 15 Class B compliance in an independent (third party) FCC-certified testing lab. Contractor shall provide costs for all the FCC third party testing and sample fixtures.

4. LED modules shall include the following features unless otherwise indicated:

   a. Comply with IES LM-79 and LM-80 requirements.
   b. Minimum CRI 80 and color temperature 3000˚ K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
   c. Minimum Rated Life: 50,000 hours per IES L70.
   d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Down lights:

1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:

1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's written instructions and approved shop drawings.

C. Support for Recessed and Semi-Recessed Grid-Type Fixtures: Units shall not be solely supported from suspended ceiling support system. Install ceiling support system rods or wires at a minimum of 4 rods or wires for each fixture, located not more than 3 inches from fixture corners. In addition, each fixture shall be supported at each corner with 12-gage drop ceiling hanger wire. Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corner. For fixtures smaller than ceiling grid install a minimum of 4 rods or wires for each fixture at corner of ceiling grid where fixture is located. Do not support fixtures by ceiling acoustical panels. Center in acoustical panel. Support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

D. Support for Suspended Fixtures: Supports for pendant mounted fixtures shall comply with the following, unless otherwise noted on drawings:
   1. Brace pendants and rods over 48 inches long to limit swinging.
   2. Support stem-mounted, single-unit, suspended fixtures with twin-stem hangers.
   3. For continuous rows, use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of chassis, including one at each end.

E. Wall-Mounted Luminaires:
   1. Attached to structural members in walls or attached to wall using through bolts and backing plates on either side of wall.
   2. Do not attach luminaires directly to gypsum board.

F. Lamping: Lamp units according to manufacturer's instructions.

G. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.2 CONNECTIONS

A. Electrical connections, all mating surfaces and connections shall be between cleaned bare metal to bare metal surfaces.

B. Ground lighting units. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A. External bonding jumpers are not required across lighting fixture flexible conduit.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components. Give advance notice of dates and times for field tests. Provide instruments to make and record test results.

B. Tests: Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source. Interrupt electrical energy to demonstrate proper operation of emergency lighting installation. All fixtures shall be energized upon completion of installation for a period of 72 hours, upon which Contractor shall replace any lamps or ballasts, which are not operating properly. Replace or repair malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly. Report results of test.

C. Warranty Period: Replace fixtures that show evidence of corrosion during warranty period.

3.4 ADJUSTING AND CLEANING

A. Clean fixtures after installation. Use methods and materials recommended by manufacturer. Adjustable fixtures shall be aimed in the presence of the Contracting Officer's Representative to provide required lighting intensities.

3.5 DISPOSAL

A. Removing Materials: Remove and dispose of the light tubes/bulbs and ballasts in accordance with applicable State and local rules and regulations

END OF SECTION 26 51 19

SECTION 265219 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

a. Testing Agency Certified Data: For indicated signs, photometric data certified by a qualified independent testing agency. Photometric data for remaining signs shall be certified by manufacturer.
b. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule:
1. For exit signs. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which equipment will be attached.
5. Size and location of initial access modules for acoustical tile.
6. Items penetrating finished ceiling including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Ceiling-mounted projectors.
e. Sprinklers.
f. Access panels.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Provide seismic qualification certificate for each piece of equipment.

E. Product Test Reports: For each luminaire for tests performed by a qualified testing agency.

F. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Material Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Material Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Material Completion. Full warranty shall apply for the entire warranty period.
2. Warranty Period for Self-Powered Exit Sign Batteries: Five years from date of Material Completion. Full warranty shall apply for the entire warranty period.

PART 2 - PRODUCTS

2.1 EXIT SIGNS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1.
2. Lighting Control and Design; Acuity Lighting Group, Inc.
3. NextGen Lighting
4. Lightolier; a Philips group brand
5. Cooper Lighting, an Eaton business

B. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size.

C. Internally Lighted Signs:

1. Operating at nominal voltage of 120 V av, or 277 V ac.
2. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
3. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
5. Master/Remote Sign Configurations:

a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.2 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Housings:

1. Extruded aluminum housing and heat sink.
2. White painted finish.

D. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

2.3 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.4 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Material Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, batteries, signs, or luminaires that are defective.
   a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265219

SECTION 26 56 00 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes exterior lighting fixtures, lamps, ballasts, pole standards, and accessories.

1.2 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications listed below are referenced as the latest edition published as of the date of this document. The publications are referred to within the text by the basic designation only.

1. American Association of State Highway and Transportation Officials (AASHTO)

   a. AASHTO LTS-3 Structural Supports of Highway Signs, Luminaires and Traffic Signals

2. American National Standards Institute (ANSI)

   a. ANSI C2 National Electric Safety Code
   b. ANSI C78 Standard for Electric Lamps
   c. ANSI C82.6 Reference Ballasts for High-Intensity Discharge Lamps - Methods of Measurement

3. ASTM International (ASTM)

   a. ASTM B 429 Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube

4. FAA Orders and Standards:

   a. FAA-STD-1391B Installation and Splicing of Underground Cables

5. Federal Standards (FS)

   a. FS JC-30 Cable and Wire, Electrical

6. National Fire Protection Association (NFPA)

   a. NFPA 70 National Electrical Code

7. Occupational Safety and Health Administration (OSHA)

a. 29 CFR 1910.7 Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)
b. IES LEM-3-13 Upgrading Lighting Systems in Commercial and Institutional Spaces.
c. IESNA Handbook Latest Version
d. UFC Unified Facilities Criteria
e. UFC 5-350-01 Interior and Exterior Lighting Systems and Control

8. Underwriters Laboratories (UL)
   a. 8750:Light Emitting Diode (LED) Light Sources for Use in Lighting Products.
   b. 773: Plug-In Locking Type Photocontrols for Use with Area Lighting.

9. Federal Communications Commission (FCC):
   a. Title 47, Part 15: Radio Frequency Devices

1.3 DEFINITIONS

A. Fixture: Provide a complete lighting device. Fixtures include a lamp or lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply.

B. Lighting Unit: A fixture or an assembly of fixtures with a common support, including a pole or bracket plus mounting and support accessories.

C. Luminaire: A complete lighting unit consisting of a light source, such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source, ballast, or distribute the light. A lamp holder itself is not a luminaire.

1.4 SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00, “Submittal Procedures.”

A. Shop Drawings

1. Detailing nonstandard fixtures and poles indicating dimensions, weights, method of field assembly, components, and accessories.
2. Wiring diagrams detailing wiring for control system showing both factory-installed and field-installed wiring for specific systems of project, and differentiating between factory-installed and field-installed wiring.
3. Anchor-bolt templates keyed to specific poles and indicating dimensions, weights, method of field assembly, components, and accessories.

B. Product Data

1. Product Data describing fixtures, lamps, ballasts, drivers, poles, and accessories. Arrange Product Data for fixtures in order of fixture designation. Include data on features, poles, accessories, finishes. Provide outline drawings indicating dimensions and principal features of fixtures and pole.

B. Design Data: Wind resistance calculations certified by a registered professional engineer.

C. Test Reports

1. Field test reports indicating and interpreting test results specified in PART 3 of this Section.
2. Electrical Ratings and Photometric Data
3. Certified results of independent laboratory tests for fixtures and lamps.
4. Contractor shall submit photometric calculations for review if the exterior lights used are substitutes to the exterior lights used in design.
5. Photometric calculation drawing showing that as-built condition meets or exceeds design light levels.

D. Operation and Maintenance Data: Prepare and distribute operations and maintenance data as specified in Section 01 78 23, “OPERATION AND MAINTENANCE DATA.”

E. Substitutions: Contractor shall submit in accordance with Section 01 25 00 “SUBSTITUTION PROCEDURES”

1.5 QUALITY ASSURANCE

A. Provide components that comply with NFPA 70 and that are listed and labeled by UL. Comply with ANSI C2.

B. Listed and Labeled: Provide fixtures and accessories specified in this Section that are listed and labeled for their indicated use and installation conditions on Project. The Terms "Listed" and "Labeled" are as defined in NFPA 70, Article 100.

C. A Listing and Labeling Agency: A Nationally Recognized Testing Laboratory (NRTL) as defined in 29 CFR 1910.7.

1.6 STORAGE AND HANDLING OF POLES

A. Store poles on decay-resistant treated skids at least above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation. Retain factory-applied pole wrappings until just before pole installation. for poles with nonmetallic finishes, handle with web fabric straps.

1.7 WARRANTY

A. The special warranty specified in this Article shall not deprive the Government of other rights the Government may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: Submit a written warranty signed by the manufacturer and Installer agreeing to replace external parts of lighting fixtures exhibiting a failure of finish as specified below. This warranty is in addition to, and not a limitation of, other rights and remedies the

Government may have under the Contract Documents. Warranty period shall be 5 years from date of Substantial Completion.

C. Protection of Metal from Corrosion: Warranty against perforation or erosion of finish due to weathering.

D. Color Retention: Warranty against fading, staining, and chalking due to effects of weather and solar radiation.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Provide 1 lamp for each type and rating installed. (For group relamping when lamps have reached 70 percent of rated life).
2. Provide 1 each glass and plastic lenses, covers, and other optical parts for every 100 of each type and rating installed. Furnish at least one of each type.
3. Provide 1 ballast/driver for every 100 of each type and rating installed. Furnish at least one of each type.
4. Provide 1 each globe and guard for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Comply with the requirements specified in the Articles below and lighting fixture schedule indicated on the drawings. The fixtures specified in the lighting fixture schedule on the Drawings establish a level of quality and appearance that any substituted fixtures must match or exceed. Substitutions for the specified fixtures will be reviewed by the COTR for compliance and approval. All lighting fixtures shall be UL approved and shall bear the UL label.

2.2 FIXTURES AND FIXTURE COMPONENTS

A. Metal Parts: Free from burrs, sharp edges, and corners.

B. Sheet Metal Components: Corrosion-resistant aluminum, cast metal and steel, except as otherwise indicated. Form and support to prevent warping and sagging.

C. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed fixtures.

D. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without the use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange for door opening to disconnect ballast.

E. Exposed Hardware Material: Stainless steel.

F. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

H. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor mounting in fixture doors.

I. Factory-Installed Photocell: Factory installed photocell in an electrical compartment with fully gasketed sensor on the end of each fixture facing the pole.

J. Operating Voltage: Match system voltage.

K. Lamps: Comply with ANSI C78 series that is applicable to each type of lamp. Provide fixtures with indicated lamps of designated type, characteristics, and wattage, including LED lamps for the bollard fixtures, parking lot pole lights, wall packs, etc. Where a lamp is not indicated for a fixture, provide medium wattage lamp recommended by manufacturer. In locations where multiple lamps or fixtures are present, color temperature should be the same.

L. Fixture Wiring: Fixture wiring shall be thermoplastic insulated copper, rated for 600 volts, in accordance with FS JC-30 and NFPA 70.

M. Provide floodlighting luminaires which are enclosed and gasketed vapor-tight fixtures in accordance with IES HB-10 and UL 1029.

2.3 FIXTURE SUPPORT COMPONENTS

A. Pole-mounted fixtures shall conform to AASHTO LTS-3. Wind-load strength of total support assembly, including pole, arms, appurtenances, base, and anchorage, is adequate to carry itself plus fixtures indicated at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 90 miles/hour with a gust factor of 4.1. Arm, bracket, and tenon mount materials shall match poles' finish. Mountings, fastenings, and appurtenances shall be corrosion-resistant items compatible with support components. Use materials that will not cause galvanic action at contact points. Use mountings that correctly position luminaire to provide indicated light distribution. Pole shafts shall be round and non-tapered. Pole bases shall be anchor type with galvanized steel hold-down or anchor bolts, leveling nuts, and bolt covers.

B. Provide access handhole in pole wall.

C. Metal Pole Grounding Provisions: Welded 1/2-inch threaded lug, accessible through handhole.

D. Pole Foundations: Use 3000 pounds per square inch gauge strength, 28-day concrete.

2.4 FINISHES

A. Metal Parts: Manufacturer's standard finish, except as otherwise indicated, applied over corrosion-resistant primer, free of streaks, runs, holidays, stains, blisters, and similar defects.

B. Other Parts: Manufacturer's standard finish, except as otherwise indicated.

2.5 LED LUMINAIRE

A. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.

B. For LED luminaires, include computer-generated photometric analysis of the "designed to" values for the "end of useful life" of the luminaire installation using a light loss factor of 0.7.

C. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections shall be obtained from testing in accordance with IES LM-80.

D. Submit report on manufacturer's standard production LED package, array, or module.

E. Warranty shall include replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

F. LED luminaire housings shall be die cast or extruded aluminum.

G. LED luminaires shall be rated for operation within an ambient temperature range of minus 30 degrees C minus 22 degrees F to 50 degrees C 122 degrees F.

H. Luminaires shall be UL listed for wet locations per UL 1598. Optical compartment for LED luminaires shall be sealed and rated a minimum of IP65 per NEMA IEC 60529.

I. LED luminaires shall produce a minimum efficacy as shown in the following table, tested per IES LM-79. Theoretical models of initial raw LED lumens per watt are not acceptable.

J. LED Light Sources - Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377. Nominal CCT: 4000 degrees K: 3985 plus or minus 275 degrees K. Color Rendering Index (CRI) shall be greater than or equal to 70 for 4000 degrees K light sources.

K. Color Consistency: Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistency of LEDs used in luminaires.

L. LED Power Supply Units (Drivers) - UL 1310. LED Power Supply Units (Drivers) shall meet the following requirements: Minimum efficiency shall be 85 percent. Drive current to each individual LED shall not exceed 600 mA, plus or minus 10 percent. Shall be rated to operate between ambient temperatures of minus 30 degrees C minus 22 degrees F and 50 degrees C 122 degrees F. Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal. Operating frequency shall be: 50 or 60 Hz. Power Factor (PF) shall be greater than or equal to 0.90. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent. Shall meet requirements of 47 CFR 15, Class B. Shall be RoHS-compliant. Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.

M. Comply with FCC requirements per CFR Title 47 Part 15 Class B:

1. CFR Title 47 Part 15 Class B compliance to be documented via formal testing which must be developed by the LED luminaire assembly manufacturer. Testing must be performed in a FCC-certified testing lab. The project engineer of record (A/E or as applicaBLE)must assure that CFR Title 47 Part 15 Class B compliance is formally stated in the luminaire (lamp, driver, enclosure assembly, as applicable) or luminaire upgrade kit shop drawing/cut sheet/engineering data book and the lighting schedule.
2. Providing the FCC CFR Title 47 Part 15 Class B testing results/report is an A/E and/or Performance Contract provider responsibility during the schematic design phase (10%) and/or IGA (investment grade audit) phase.
   After the 10% submission, FAA will take the responsibility to review and approve/comment/make recommendations/reject the LED fixtures based on the FCC testing results/report review.
3. If a proposed luminaire assembly or upgrade kit is meant to serve a custom application based on a FAA request and the luminaire assembly or upgrade kit is not FCC CFR Title 47 Part 15 Class B compliant and/or the FCC testing was not performed in a FCC-certified testing lab, the project contractor must provide one sample fixture per each type to be tested for CFR Title 47 Part 15 Class B compliance in an independent (third party) FCC-certified testing lab. Contractor must provide costs for all the FCC third party testing and sample fixtures.

N. Power supplies in luminaires mounted under a covered structure, such as a canopy, or where otherwise appropriate shall be UL listed with a sound rating of A.

O. LED drivers shall be dimmable, and compatible with a standard dimming control circuit of 0 - 10V or other approved dimming system.

P. LED drivers shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

Q. LED Luminaire Surge Protection - Provide surge protection integral to luminaire to meet C Low waveforms as defined by IEEE C62.41.2, Scenario 1, Location Category C.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set units plumb, square, level, and secure according to manufacturer's written instructions and approved shop drawings.

B. Concrete Foundations: Comply with details and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished. Trowel and rub smooth parts exposed to view.

C. Pole Installation: Use web fabric slings (not chain or cable) to raise and set poles.

D. Fixture Attachment: Fasten to indicated structural supports.

E. Lamp Fixtures: Lamp fixtures with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.

3.2 GROUNDING

A. Ground fixtures and metal poles according to Section 26 05 26, “Grounding and Bonding for Electrical Systems.”

B. Poles: Install 10-foot driven ground rod at each pole.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed unit for damage. Replace damaged fixtures and components. Give advanced notice of dates and times for field tests. Provide instruments to make and record test results. Verify normal operation of lighting units after installing fixtures and energizing circuits with normal power source. Include photometric tests to measure light intensities at night at locations where specific illumination performance is indicated. Use photometers with calibration referenced to National Institute of Standards and Technology (NIST) standards. Check for intensity of illumination. Check for uniformity of illumination. Check for excessively noisy ballasts. Prepare written report of tests indicating actual illumination results. Replace or Repair damaged and malfunctioning units, make necessary adjustments, and retest. Repeat procedure until all units operate properly.

END OF SECTION 26 56 00

SECTION 33 25 30 – SANITARY SEWERS

PART 1 GENERAL

1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 48 ....(1994) Gray Iron Castings

ASTM A 307 ....(1994) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

ASTM D 1557 ....(1991) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft- lbf/ft3 (2,700kN-m/m3))

AMERICAN WATER WORKS ASSOCIATION (AWWA)

C105 ....Polyethylene Encasement for Ductile-Iron Piping For Water and Other Fluids

C110...Ductile-Iron and Grey-Iron Fittings, 3in. Through 48 in., For Water and Other Fluids

C111...Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

C115...Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges

C151...Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, For Water or Other Liquids

1.2 GENERAL REQUIREMENTS

The construction required herein shall include appurtenant structures and building sewers to points of connection with the building drains to which the sewer system is to be connected. The Contractor shall replace damaged material and redo unacceptable work at no additional cost to the Government. Backfilling shall be accomplished after inspection by the COR. Before, during and after installation, pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material.

1.3 Submittals

The following shall be submitted in accordance with Section 01 33 00, "SUBMITTAL PROCEDURES."

1. Certificates for piping material

PART 2 PRODUCTS

2.1 DUCTILE IRON PIPE (DIP) and FITTINGS

The pipe shall be lined ductile iron (DIP) with a minimum thickness of Class 51 for 3 and 4 inch diameter pipe and Class 50 for larger pipe. Fittings may be ductile iron or cast iron unless otherwise noted.

a) Pipe shall be ANSI A21.51 (AWWA C151).
b) Fittings shall be ANSI/AWWA C110
c) Mechanical and Push-on Joints shall conform to be ANSI A21.11 (AWWA C111).
d) Flange Joints shall conform to ANSI A21.10 and A21.15 (AWWA C110 and C115), Class 125 with 1/8 inch full faced rubber gaskets.
e) Restrained Joints shall be ductile iron mechanical joint retainer glands manufactured by American Cast Iron Pipe Co. or an approved equal.
f) Flexible Joints shall be boltless with 15 degrees joint deflection per applicable portions of ANSI A21-10 (AWWA C110) as manufactured by "Flex-Lok" by American Cast Iron Pipe Co., or an approved equal.
g) Bolts shall conform to AWWA C110 and nuts shall conform to AWWA C110 of low carbon steel per ASTM A307, Grade B.

2.3 COATINGS and LININGS (IRON PIPE)

All pipe and fittings shall have a protective interior lining. The lining shall be a ceramic epoxy material such as Protecto 401 or Permite 9043 or shall be heat bonded polyethylene. All linings shall be applied to a finished thickness of 40 mils. Polyethylene shall be virgin material complying with ASTM D 1248 compounded with sufficient carbon black to resist ultraviolet rays during above ground storage. Polyethylene encasement, where required, shall be per ANSI A21.5 (AWWA C105). If polyethylene encasement is not required, the pipe exterior shall be bituminous coated.

PART 3 EXECUTION

3.1 GENERAL

Trench excavating and backfill including sheeting and bracing, dewatering, bedding and foundation, and furnishing and disposal of materials shall be performed in such a manner as to promote the safe and expedient execution of the work.

3.1.1 Protection of Water System Crossings

Where the horizontal separation between sanitary sewer and potable water lines is less than 10 feet, the sewer pipe shall be constructed of lined ductile iron pipe with high pressure joints. Where the sewer pipes cross any potable water lines with a vertical clearance of less than 18 inches, a minimum of 10 feet each side of the crossing shall be high pressure joint polyethylene lined ductile iron pipe.

3.2 PIPELINE TRENCHING

Excavation of trenches shall not advance more than 50 feet ahead of completed pipe installation except as approved by the COR. Excavation in close proximity to existing utilities shall be performed in a manner to prevent damage. Representatives of utilities shall be contacted for assistance in locating buried lines.

All excavations may be made by open cut. Sides of trenches shall be kept as nearly vertical as possible from the trench bottom to a level of one foot above the top of the pipe. Trench bottoms shall be excavated true to line and shall be not less than 18 inches wide or more than 24 inches wider than the outside diameter of the pipe so a clear space of 9 to 12 inches is provided on each side of the pipe. Minimum trench width for small diameter pipe shall be 24 inches. Grade of the trench bottom Representative of the utilities including the Airport and FAA shall be consistent with the method of bedding specified herein.

3.3 SHEETING, SHORING, AND BRACING

Furnish, install, and maintain sheeting, bracing, and shoring support or trench shielding required to keep excavations within the easement or right-of-way, to support the sides of the excavation, and to prevent any movement which may damage adjacent pavements or structures, damage or delay the work, or endanger life and health. Voids outside the supports shall be immediately filled and compacted. Sheeting, bracing, and shoring to be used shall be designed by a Florida Registered Professional Engineer. All trenching shall be performed in compliance with the OSHA Trench Safety Act.

3.4 DEWATERING AND DRAINAGE

At all times during construction keep excavations free from standing water. Sumps, if required, shall be located outside of load bearing areas so the bearing surfaces will not be disturbed. Water pumped from the excavation shall be discharged to prevent re-entry into the soil strata being dewatered. Water containing silt in suspension shall not be pumped into storm lines or adjacent streams. The method of disposing of water pumped from the excavation shall be approved by the COR, prior to actual disposal. <u>The sanitary sewer system shall not be used to dispose of dewatering drainage.</u> Following completion of dewatering activities, contractor shall fill all well point holes with flowable fill or pea gravel for the entire depth.

3.5 STABILIZATION

If portions of the bottom of trenches or excavations consists of material unstable to such a degree that, in the opinion of the COR, it cannot adequately support the pipe or structure, the bottom shall be over-excavated a minimum of 6 inches and stabilized with 3/4" stone or smaller approved coarse granular stabilization material. Depth of stabilization shall be as directed by the COR.

3.6 BEDDING OF PIPING

3.6.1 General

Haunching is defined as the shaped and tamped granular material that extends from the pipe bedding to the springline of the pipe. Cover is defined as the compacted material which protects and covers piping, and which extends from the top of haunching material to a point one foot above the top of the pipe. Backfill, as specified hereafter, is defined as the material extending above the top of pipe cover to topsoil, paving subgrade, or foundation level. All buried piping shall be continuously bedded and covered, except where concrete encasement, concrete cradles or boring and jacking are indicated.

3.6.2 Pipe Bedding

Any part of the trench bottom that is excavated below the pipe grade shall be backfilled to grade with a minimum of 6 inches of granular material and compacted as required above.

3.6.3 Pipe Cover

All cover materials shall be clean fill with no debris and carefully deposited to avoid damage to the pipe and shall be compacted as specified hereafter.

3.7 TRENCH BACKFILLING

Backfill shall be granular material or suitable previously excavated pipe trench material approved for use by the COR. The granular backfill shall be carefully deposited in uniform lifts as specified below and each lift shall be wetted adequately as needed to obtain the required compaction density with vibratory compactors, as specified hereafter.

Unless otherwise indicated or approved by the COR, fills shall be placed in the loose lift thickness indicated hereafter and compacted to a dry density not less than the following percentage of maximum dry density, determined by the Modified Proctor Test, ASTM D1557 unless otherwise noted.

Type of Fill	Usage	Thickness	% ASTM	
Trenched Pipe Foundation, Bedding and Hauling	Beneath piping	6"	95	D1557
Trenched Pipe Cover	Over and/or around piping	6"	95	D1557
Utilities Trench Backfill	“Influence area” beneath other piping or utility lines	8"	95	D1557
	“Influence area” beneath rigid paving and railroad tracks	6"	98	D1557
	“Influence area” beneath non-rigid paving	9"	98	D1557
	Adjacent to or under structures	9"	98	D1557
	Cropland, plant site, lawns and landscaped areas	12"	85	D1557
Structural Fill	All locations under minor structures (manhole, etc.)	8"	95	D1557
Granular Fill	Below concrete slab bedding, foundations, rigid paving and excavated areas adjacent to structures	8"	98	D1557
Granular Bedding	Beneath concrete slabs	12"	90	D1557

General Site Grading Not Covered Herein	Fill in other locations	12"	85	D1557
	Topsoil placement	12"	85	D1557

"Influence area" shall be considered the area within lines sloped downward at 45 degrees from the outer edges of paving, foundations, and utility lines.

3.8 PIPE LAYING and JOINTING

Gravity sewers shall be laid in the dry to the elevations and slopes shown on the approved construction drawings. Laser equipment shall be used to provide line and grade. Surveying equipment shall be used to set the laser. The laser equipment shall have a slope indicator to facilitate checking by both the pipe laying foreman and the COR. Since most gravity sewers are laid with extremely flat slopes, zero tolerance for errors in line and grade will be allowed. Upon completion of the work, the contractor shall clean the system, with all debris removed at downstream manhole. Any pipe defects such as bellies or other deformities shall be taken up and re-laid to provide the correct line and grade. Special attention shall be given to the requirement that the pipe be laid in a dry trench with properly compacted bedding and with properly compacted backfill. The pipe shall be laid with the spigot ends pointing in the direction of flow starting at the lowest point. Joint contact surfaces shall be cleaned immediately prior to jointing. Lubricants, primers, or adhesives shall be used as recommended by the joint manufacturer. The minimum allowable cover for gravity sewers shall be 3 feet from the top of the pipe to the finish grade. However, should this depth not be feasible, or where grade depressions along the alignment are unavoidable, ductile iron pipe shall be provided within the limits of the lesser cover. In no case shall the pipe cover be less than 18 inches, unless special design considerations have been approved by the Bureau of Waste Water. Pipes shall be installed to the alignment and grade as shown on the approved plans.

3.9 BRANCHES

Wye branches are to be installed in conjunction with the laying of sewer pipe. Wyes to serve all existing and future dwelling units shall be installed. The longitudinal barrel of branch fittings shall conform to the line and grade, diameter and quality of the sewer main. All service laterals shall be perpendicular to the longitudinal axis of the pipe.

3.10 DOWNSTREAM PROTECTION

Dirt and debris collected in the pipe during construction shall not be flushed downstream. The open end of pipe shall be closed daily to prevent foreign matter from entering.

3.11 TESTING

3.11.1 Cleaning

All main pipelines, laterals, and manholes shall be cleaned and all debris removed using high-velocity jet equipment (Hydro cleaning). All high-velocity sewer cleaning equipment shall be constructed for ease and safety of operation. The equipment shall have a selection of two or more high-velocity nozzles. The nozzles shall be capable of producing a scouring action from 15 to 45 degrees in all size lines designated to be cleaned. Equipment shall also include a high-velocity gun for washing and scouring manhole walls and floor. The gun shall be capable of producing flows from a fine spray to a solid stream. The equipment shall carry its own water tank, auxiliary engines, pumps, and hydraulically driven hose reel.

3.11.2 Infiltration/Exfiltration

There shall be no detectable level of infiltration or exfiltration from the system at the time of inspection. Any evidence of leakage must be corrected prior to acceptance. This includes laterals, main lines, and manholes.

3.12 TESTING PRIOR TO RESURFACING

All tests shall be completed and accepted by the COR prior to the placement of backfill over sewer lines. Both private systems and those to be dedicated to the City may be televised by City staff to determine if any defects are present in the system. Prior to requesting an inspection, the contractor shall be responsible for removing all dirt and debris from the sewer system and installing a stabilized driving surface that allows access to all manholes. Inspection requests shall be made 48 hours in advance.

3.13 FINAL INSPECTION

After all backfill and grading operations are completed, a final visual inspection shall be made by the COR. All manholes shall be examined for proper grade and water tightness. The contractor shall assist the COR by providing all labor as required. The contractor shall make note of any corrections required and shall perform all remedial actions prior to the acceptance by the FAA.

3.14 IDENTIFICATION

All pipe shall be buried with identification tape above the top of the pipe. The tape shall indicate the presence of gravity sanitary sewers plainly on the tape face. Indicator tape buried with pipe shall be able to be detected by standard metal detection equipment, as manufactured by Terra Tape Detectable, or approved equal.

END OF SECTION 33 25 10

APPENDIX 1

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FAA-STD-019f
October 18, 2017

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

STANDARD

LIGHTNING AND SURGE PROTECTION, GROUNDING, BONDING, AND SHIELDING REQUIREMENTS FOR FACILITIES AND ELECTRONIC EQUIPMENT

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FOREWORD

1. Construction of Federal Aviation Administration (FAA) operational facilities and the electronic equipment installed therein shall conform to this standard. This standard defines minimum requirements for FAA facilities. When specific needs of a facility exceed these minimum requirements, the facility design and construction shall meet the specific needs. The equipment type, configuration, and location along with the configuration of site structures and environmental/weather conditions influence these needs.

2. The requirements herein reflect lessons learned from investigation and resolution of malfunctions and failures experienced at field locations. The FAA thus considers these requirements the minimum necessary to harden sites sufficiently for the FAA missions – to prevent delay or loss of service, to minimize or preclude outages, and to enhance personnel safety. Further, the requirements herein are coordinated with industry standards, and in some cases exceed industry standards where necessary to meet the FAA missions.

3. The use of “shall” or verbs such as “provide,” “construct,” “weld,” or “connect” indicates mandatory compliance. Deviations are permissible in cases when implementation of certain requirements is not technically feasible, and in such cases, the FAA shall submit a National Airspace System (NAS) Change Proposal (NCP) with justification and technical documentation, and receive approval by the NAS Configuration Control Board (CCB).

4. The format and content requirements of this standard are in accordance with FAA-STD-068, and the grammar and style are in accordance with the Government Printing Office (GPO) Style Manual.

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TABLE OF CONTENTS

1 SCOPE 1
1.1 Applications 1
1.2 Tailoring of Mandatory Requirements 1
1.3 Purpose 1
1.4 Content Organization 2
2 APPLICABLE DOCUMENTS 5
2.1 General 5
2.2 Government Documents 5
2.2.1 FAA Specifications 5
2.2.2 FAA Orders and Handbooks 5
2.2.3 Military Documents 5
2.3 Non-Government Documents 6
2.3.1 Electronic Industries Alliance (EIA) 6
2.3.2 National Fire Protection Association (NFPA) 6
2.3.3 Underwriters Laboratories (UL) 7
2.3.4 Institute of Electrical and Electronic Engineers (IEEE) 7
2.3.5 Electrostatic Discharge (ESD) Association Documents 7
2.3.6 Telecommunication Industry Association (TIA) Documents 7
3 DEFINITIONS 9
4 GENERAL REQUIREMENTS 15
4.1 Introduction 15
4.2 Bonding Requirements 15
4.2.1 General 15
4.2.2 Dissimilar Metals 15
4.2.3 Methods of Bonding 17
4.2.4 Bonding Connections – Installation Requirements 21
4.2.5 Bonding Connections – Hardware for Bonding Jumpers and Straps 22
4.3 Lightning Protection System Requirements 24
4.3.1 General 24
4.3.2 Lightning Protection System – Components 24
4.3.3 Lightning Protection System – Material Class Requirements 24
4.3.4 Lightning Protection for NAS Facilities Buildings and Structures 24
4.3.5 Lightning Protection System - Conductor Routing 25
4.3.6 Lightning Protection System - Air Terminals 28
4.3.7 Lightning Protection System - Hardware 29
4.3.8 Lightning Protection System – Bonding Connections 30
4.4 Earth Electrode System (EES) 32
4.4.1 General 32
4.4.2 [A3] Site Survey and Geotechnical Investigation 32
4.4.3 EES – Design 32
4.4.4 EES - Configuration 32
4.4.5 Grounding Enhancement Materials for Earth Electrode System (EES) Installation 35
4.4.6 Installation of Earth Electrode Systems in Corrosive Soils 36
4.5 National Electric Code - Power Distribution System Grounding Compliance 38
4.5.1 General 38
4.5.2 Grounding Electrode Conductors (GEC) 38
4.5.3 Equipment Grounding Conductors (EGC) 38

4.5.4 Grounding Bushings for Conduit Raceways 38
4.5.5 Interior Metal Piping Systems 41
4.5.6 Building Structural Steel 41
4.6 Surge Protection Device (SPD) Requirements 42
4.6.1 General 42
4.6.2 SPD for Power Distribution System 42
4.6.3 SPD for Signal, Control, and Data Line Surge Protection 45
4.7 Grounding and Bonding for NAS Electronic Equipment Areas 46
4.7.1 General 46
4.7.2 Main and Supplemental Ground Plates 46
4.7.3 Signal Reference Structures (SRS) – Requirements 48
4.7.4 Bonding of Electrical Systems in NAS Electronic Equipment Areas 56
4.8 Shielding Requirements 57
4.8.1 General 57
4.8.2 Facility Shielding 57
4.8.3 Shielding for Conductors and Cabling 57
4.8.4 Electromagnetic Environment Control 61
4.9 Electrostatic Discharge (ESD) Requirements 62
4.9.1 General 62
4.9.2 Requirements 62
5 DETAILED REQUIREMENTS 64
5.1 Introduction 64
5.2 Airport Traffic Control Tower (ATCT) Facilities 65
5.2.1 General 65
5.2.2 Lightning Protection System 66
5.2.3 Main Ground Connections 67
5.2.4 Power Distribution System 71
5.2.5 NAS Electronic Equipment Areas 71
5.3 Lightning Protection System – Special Conditions 73
5.3.1 General 73
5.3.2 Antenna Towers 73
5.3.3 Antenna Protection 76
5.3.4 Tower Guying 76
5.3.5 Waveguide, Axial Cable, and Conduit Grounding 76
5.3.6 Staircase and Ladder Protection 76
5.3.7 Lightning Protection for Facilities without Buildings or Antennas 77
5.3.8 Lightning Protection for Fences and Gates 77
5.3.9 Lightning Protection for Photovoltaic Solar Arrays 78
5.4 Facility Transient Protection – Special Conditions 80
5.4.1 General 80
5.4.2 Existing Metallic Conduit, Conductors, and Cables 80
5.4.3 Electromagnetic Shielding for Lines, Conductors, and Cables 80
5.4.4 Balanced Pair Cables 84
5.4.5 Fiber Optic Cable 84
5.4.6 Interior Wiring, Conductors, and Cables 85
5.5 Single Point Ground System (SPG) – Special Conditions 86
5.5.1 General 86
5.5.2 Isolation between SPG and Other SRS Systems 86
5.5.3 Resistance of Bonds 86
5.5.4 SPG - Ground Plates 86
5.5.5 SPG - Ground Conductors 86
5.5.6 Labeling 87

5.5.7 Protection ... 87
5.6 NAS Electronic Equipment – Interface and Procurement Requirements ... 89
5.6.1 General ... 89
5.6.2 Electronic Signal Lines and Cables - Shielding ... 89
5.6.3 Signal, Control, and Data Line Entrance – Transient Protection ... 89
5.6.4 Equipment Power Entrance – Transient Protection ... 90
5.6.5 NAS Electronic Equipment Enclosures and Assemblies - Grounding and Bonding ... 93
5.6.6 NAS Electronic Equipment – Equipment Grounding and Bonding ... 96
5.6.7 Equipment Shielding Requirements ... 98
5.6.8 NAS Electronic Equipment - Electrostatic Discharge Protection ... 99
5.6.9 Secure Facilities ... 100
5.6.10 High RF Field Bonding Requirements ... 100
5.7 Surge Protective Device (SPD) – Equipment Specification Requirements ... 100
5.7.1 General ... 100
5.7.2 Surge Protective Device (SPD) for Power Distribution Equipment Protection ... 100
5.7.3 SPDs for NAS Electronic Equipment – Design and Procurement Requirements ... 104
5.7.4 SPD - Design Specification for Axial Cable Protection ... 104
5.8 Electrostatic Discharge (ESD) Protection – Interface and Specification Requirements ... 105
5.8.1 General ... 105
5.8.2 Electrostatic Discharge (ESD) Sensitivity Classification ... 105
5.8.3 Classification of Materials ... 105
5.8.4 Hard and Soft Grounds ... 106
5.8.5 Protection of Electrostatic Discharge (ESD) Susceptible and Sensitive Items ... 107
5.8.6 ESD Controls Required for ESD Special Protection Areas ... 107
5.8.7 ESD Signs, Labels, Cautions, and Warnings for ESD Protection Areas ... 109
5.8.8 Electrostatic Discharge (ESD) Protective Storage Areas ... 109
5.8.9 Electrostatic Discharge (ESD) Control Flooring and Floor Coverings ... 110
5.8.10 Electrostatic Discharge (ESD) Requirements for Raised Access Floor Systems ... 110
5.8.11 Electrostatic Discharge (ESD) Protective Worksurfaces ... 111
5.8.12 Static Dissipative Coatings ... 112
5.8.13 Electrostatic Discharge (ESD) Protected Workstations ... 112
5.9 Electromagnetic Compatibility Requirements ... 113
5.9.1 General ... 113
5.9.2 [A6] Requirements ... 113
5.9.3 Approval ... 113
6 NOTES ... 115
6.1 Acronyms and Abbreviations ... 115
6.2 Guidelines and Reference Notes ... 118
6.3 Version Cross-Reference ... 118
6.4 Bibliography ... 119

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List of Figures

Figure 1. Order of Assembly for Bolted Connections 21
Figure 2. Lightning Protection System Main Conductor Connections – Illustrative Example 27
Figure 3. Main and Down Conductor Termination to EES – Illustrative Example....................28
Figure 4. Typical Service Rack EES Installation – For Illustrative Purposes Only 33
Figure 5. Grounding Trench Detail....................37
Figure 6. Ground Dissipation Plate Detail....................37
Figure 7. Bonding of Grounding Conductor to Conduit or Equipment....................40
Figure 8. SPD Location Diagram - Close Proximity Allowance Decision Tree 44
Figure 9. Typical Facility Grounding System....................47
Figure 10. Multipoint Ground Conductor Size Determination....................50
Figure 11. Electronic Equipment Grounding....................54
Figure 12. Grounding of Overall Cable Shields to Connectors and Penetrating Walls....................60
Figure 13. Grounding of Overall Cable Shield to Terminal Strip 61
Figure 14. Airport Traffic Control Tower – Typical Floor Levels....................65
Figure 15. Typical Electronic Equipment Grounding Riser Diagram for ATCT (Preferred Method)....................69
Figure 16. Typical Electronic Equipment Grounding Riser Diagram for ATCT (Alternative Method)....................70
Figure 17. Lightning Protection for Radomes and Radar Antenna Platforms....................75
Figure 18. Fence Grounding 79
Figure 19. Buried Guard Wire Detail for Underground Cables or Cable Ductbanks....................84
Figure 20. Single-Point Ground System Installation – Illustrative Example....................88
Figure 21. Lines and Cables Requiring Protection 90
Figure 22. Bonding of Connectors to Mounting Surface....................95
Figure 23. Single Point Ground Bus Bar Installation in Rack or Cabinet 98

Note. *Colors in figure illustrations distinguish the fundamental elements of the grounding system concept and do not represent color-coding or labeling requirements of this standard.*

List of Tables

Table 1. Mechanical Bonds Between Dissimilar Metals....................16
Table 2. Connection Torque Requirements for Bolted Bonds....................20
Table 3. Size of Electronic Multipoint Ground Interconnecting Conductors....................51
Table 4. Ground Plate Specification Requirements....................52
Table 5. Grounding Conductor Insulation Color Codes 55
Table 6. Minimum Separation Distance between Signal and Power Conductors 62
Table 7. ATCT MPG Configuration – Parallel Conductor Complements....................68
Table 8. Electronic Equipment Power Entrance SPD - Slope Resistance (R_{slope}) 92
Table 9. Electronic Equipment Power Entrance SPD - Voltage Protection Rating (V_3)....................92
Table 10. Electronic Equipment Power Entrance SPD – Surge Current Lifetime Rating....................92
Table 11. Power Distribution Equipment SPD – Surge Current Lifetime Rating....................102
Table 12. Power Distribution Equipment SPD - Slope Resistance (R_{slope}) 103
Table 13. Power Distribution SPD Voltage (V_3) Protection Rating....................103

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1 SCOPE

This standard establishes design, procurement, installation, construction, and evaluation standards for lightning protection, transient surge protection, grounding, bonding, shielding configurations and procedures, and control of electrostatic discharge (ESD).

1.1 Applications

The requirements of this standard are mandatory for both new facilities and modifications and upgrades to existing facilities, new equipment installations, and new electronic equipment procurement used in the National Airspace System (NAS) facilities.

The use of the term “facilities” herein can differ from the manner in which it is frequently used in other Federal Aviation Administration (FAA) documents. In this standard, facilities may refer to an entire building, tower, interior or exterior system(s), or portions thereof which support the NAS and its operation. The physical proximity of the system(s) or equipment typically defines a single facility, while significant physical separation of the system or equipment defines separate facilities.

This standard covers government owned or leased property and “facilities.”

a. <u>Contractor-Owned Equipment Interface</u>. The interface between contractor-owned equipment or electronic equipment not used for operational purposes, such as administrative local area network (LAN), administrative telephone, and the operational NAS facilities shall be in accordance with this standard.

1.2 Tailoring of Mandatory Requirements

The FAA recommends that the Office of Primary Responsibility (OPR) is contacted to obtain technical guidance on the applicability of requirements herein for modifications, upgrades, and new equipment installations in existing facilities.

a. <u>Application for Previously Funded Programs</u>. This standard is not mandatory for programs funded prior to the issue date of this standard, nor is it mandatory for construction contracts associated with programs funded prior to the issue of the standard. Application of this standard is at the discretion of the user for programs funded prior to the issue of the standard.

b. <u>Mandatory Applications</u>. The OPR can mandate the use of this standard for programs started before the issue date of this standard, if funding is provided.

1.3 Purpose

The requirements of this standard provide a systematic approach to minimize electrical hazards to personnel, and minimize electromagnetic interference (EMI) that can cause damage to facilities and electronic equipment from lightning, transients, ESD, and power faults.

1.4 Content Organization

The standard is organized in accordance with FAA-STD-068.

FAA-STD-019F Content Arrangement		
FOREWORD	⇨	Normative Process Information
1 SCOPE	⇨	This chapter contains: a. Scope Statement b. Applicability Statement for mandatory compliance with requirements c. Procedure for Tailoring of Mandatory Requirements
2 APPLICABLE DOCUMENTS	⇨	This chapter includes technical documents used in this standard.
3 DEFINITIONS	⇨	This chapter contains definitions essential to the understanding and application of this standard. It is not intended to include commonly defined general or technical terms from building codes or industry standards.
4 GENERAL REQUIREMENTS	⇨	This chapter addresses the general grounding system requirements commonly included in building codes and industry standards, and covers the general common requirements and standard practice for the overall design, installation, construction, and evaluation for FAA installations. The general requirements of industry codes and standards are often too general for many FAA applications. This chapter is organized to define and build upon the requirements of general industry standards and building codes as they relate to FAA applications. This chapter includes the following parts: a. Bonding Requirements b. Lightning Protection System Requirements c. Earth Electrode System Requirements d. National Electrical Code Power Distribution System Grounding Compliance e. Surge Protective Device Requirements f. Grounding and Bonding Requirements for NAS Electronic Equipment Areas g. Shielding Requirements h. Electrostatic Discharge Requirements

FAA-STD-019F Content Arrangement (continued)		
5 DETAILED REQUIREMENTS		This chapter describes detailed performance requirements, which are specific to FAA facility applications, organized by facility special conditions and equipment as follows: a. Airport Traffic Control Tower Facilities b. Lightning Protection System – Special Conditions c. Facility Transient Protection – Special Conditions d. Single Point Ground System (SPG) – Special Conditions e. NAS Electronic Equipment – Interface and Procurement Requirements f. Surge Protective Device (SPD) – Procurement Requirements g. Electrostatic Discharge Equipment – Interface and Specification Requirements h. Electromagnetic Compatibility Requirements
6 NOTES		This chapter includes: a. Acronyms and Abbreviations b. Guidelines and References Notes c. Version Cross-Reference d. Bibliography Document conventions: Designations indicated with brackets, e.g., " [A1] " preceding a section or paragraph title denote that explanatory material is provided in section 6.2. Designations indicated with brackets, e.g., " [B1] " preceding a section or paragraph title indicates that bibliography reference material is provided in section 6.4.

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2 APPLICABLE DOCUMENTS

2.1 General

Documents listed in this chapter are government and non-government reference documents that form a part of this standard and are applicable to the extent specified herein. While every effort has been made to ensure the completeness of this list, document users are cautioned that they shall meet all specified requirements of documents cited in Chapters 3, 4, and 5 of this standard, and national safety standards, whether or not they are listed.

a. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard takes precedence. Nothing in this standard shall supersede applicable laws and regulations unless a specific exemption has been obtained.

b. Bibliography and reference source material is included in Chapter 6.

2.2 Government Documents

Due to periodic updating of government documents, the Contracting Officer and/or the Implementation Engineer shall specify the current version for project design or at contract award.

2.2.1 FAA Specifications

FAA-C-1217	Electrical Work, Interior
FAA-G-2100	Electronic Equipment, General Requirements
FAA-STD-012	Paint Systems for Equipment

2.2.2 FAA Orders and Handbooks

FAA-HDBK-010	Recommended Practices and Procedures for Lightning and Surge Protection, Grounding, Bonding, and Shielding Implementation
FAA-HDBK-011	Fundamental Considerations of Lightning Protection and Surge Protection, Grounding, Bonding, and Shielding

Copies of FAA specifications, standards, orders, and other applicable documents may be obtained from the Contracting Officer issuing the invitation-for-bid or request-for-proposal. Requests for this material should identify the material desired, for example, the specifications, standards, amendments, drawing numbers and dates. Requests should cite the use for the material, invitation-for-bid, request-for-proposal, the contract number, or other intended use.

2.2.3 Military Documents

MIL-HDBK-232	Revision A Red/Black Engineering-Installation Guidelines
MIL-HDBK-237	Electromagnetic Compatibility Management Guide for Platforms, Systems and Equipment
DOD/MIL-HDBK-263	Electrostatic Discharge Control Handbook
DOD-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipment and Facilities

MIL-PRF-87893	Performance Specification, Workstation, Electrostatic Discharge Control
MIL-W-87893	Military Specification Workstation, Electrostatic Discharge (ESD) Control
MIL-STD-461	The Control of Electromagnetic Interference Emissions and Susceptibility
MIL-STD-889	Dissimilar Metals
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
NACSIM 5203	Guidelines for Facility Design and Red/Black Installation (Confidential Document)
Single copies of Military specifications, standards, and handbooks are available by mail or telephone from Document Automation and Production Service Customer Service, Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094. http://quicksearch.dla.mil/ Not more than five items may be ordered on a single request and all requests must contain the document number. Only the latest revisions (complete with latest amendments) are available. Slash sheets must be individually requested. The Invitation for Bid or Contract Number should be cited where applicable.	

2.3 Non-Government Documents

Due to periodic updating of non-government documents, the Contracting Officer and/or the Implementation Engineer must specify the current version for project design or at contract award unless a specific version is identified in this standard. These documents form a part of this standard and are applicable to the extent specified herein. While this standard may exceed the requirements of the following documents, building codes and industry standards always shall be followed as a minimum.

2.3.1 Electronic Industries Alliance (EIA)

JEDEC Standard JESD625	Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices
Copies of EIA Standards are available from JEDEC Solid State Technology Association, Mailing Address: 3103 North 10th Street, Suite 240-S, Arlington, VA 22201-2107. https://www.jedec.org/	

2.3.2 National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code (NEC)
NFPA 77	Recommended Practice on Static Electricity
NFPA 780	Standard for the Installation of Lightning Protection Systems
Copies of NFPA documents are available from the National Fire Protection Association, One Batterymarch Park, Quincy, MA 02269. www.nfpa.org	

2.3.3 Underwriters Laboratories (UL)

UL 96	Lightning Protection Components
UL 96A	Installation Requirements for Lightning Protection Systems
UL 779 (ANSI-A148.1)	Electrically Conductive Floorings
UL 1449	Standard for Surge Protective Devices
Copies of UL documents are available from Global Engineering Documents, 1500 Inverness Way, East Englewood, CO 80112. Telephone 303-397-7945, 800-854-7179. www.ul.com	

2.3.4 Institute of Electrical and Electronic Engineers (IEEE)

ANSI/IEEE C62.41.2	Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
ANSI/IEEE C62.45	Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
ANSI/IEEE 1100	Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (Emerald Book)
Copies of IEEE documents are available from Institute of Electrical and Electronic Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-9916. www.ieee.org	

2.3.5 Electrostatic Discharge (ESD) Association Documents

ESD ADV1.0	Electrostatic Discharge Terminology - Glossary
ESD ADV53.1	ESD Protective Workstations
ESD S4.1	Worksurfaces Resistance Measurements
ANSI/ESD S8.1	Symbols - ESD Awareness
ANSI/ESD S20.20	Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment
ANSI/ESD STM 7.1	Floor Materials - Resistive Characterization of Materials
ANSI/ESD STM 11.11	Surface Resistance Measurement of Static Dissipative Planar Materials
ANSI/ESD STM 12.1	Seating - Resistive Measurement
ESD TR20.20	Handbook for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies and Equipment
ANSI/ESDA/JEDECD JS-001	ESDA/JEDEC Joint Standard for Electrostatic Discharge Sensitivity Testing - Human Body Model (HBM) - Component Level
Copies of ESD Association documents are available from the EOS/ESD Association, Inc. 7900 Turin Road, Building 3, Rome, NY 13440-2069. Telephone 315-339-6937. www.esda.org	

2.3.6 Telecommunication Industry Association (TIA) Documents

TIA-222	Structural Standard for Antenna Supporting Structures and Antennas
Copies of TIA documents are available from the Telecommunications Industry Association, 1320 North Courthouse Road, Suite 200, Arlington, VA 22201. Telephone 703-907-7700. www.tiaonline.org/standards/	

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3 DEFINITIONS

A	
Access Well	A covered opening in the earth using concrete or other cementitious material to provide access to an EES connection.
Armored Cable	Power, signal, control, or data cable having an overall armor or covering constructed of ferrous (steel) material that provides both structural protection and electromagnetic shielding for direct buried cables.
Arrester	Components, devices, and circuits used to attenuate, suppress, limit, or divert adverse electrical surge and transient energy. The terms arrester, suppressor, and protector are used interchangeably, except the term "arrester" is used herein for components, devices, and circuits installed on the primary side of FAA-owned distribution transformers.
B	
Bond	The electrical connection between two metallic surfaces used to provide a low-resistance path between them.
Bond, Direct	An electrical connection utilizing continuous metal-to-metal contact between the members being joined.
Bond, Indirect	An electrical connection employing an intermediate electrical conductor between the bonded members.
Bonding	The joining of metallic parts to form an electrically conductive path to ensure electrical continuity and the capacity to conduct current imposed between the metallic parts.
Bonding Jumper	A conductor installed to ensure electrical conductivity between metal parts required to be electrically connected.
Bonding Jumper, for NEC Compliance	See NEC definitions for power distribution wiring terms such as "Equipment", "Main", or "System" bonding jumper.
Branch Circuit	The circuit conductors between the final overcurrent protective device and the load.
Building "*Structural*" Steel	The main building structural steel members consisting of columns and beams or girders. Concrete-encased reinforcing steel rebars may be considered structural steel, depending on location.
Bulkhead Ground Plate	A metallic plate located where conduits, conductors, cables, waveguides, etc, enter the facility from the exterior. The bulkhead plate provides a central point for the grounding of these services to minimize external transients from entering the facility or structure.
Bushing	An insulated device that allows an electrical conductor to pass safely through a grounded conducting barrier such as the case of a panel, transformer, etc. The primary purpose is to prevent chafing of the conductors.
Bushing, Grounding or Bonding	An insulated device that allows for a grounding method at the end of the conduit. Also known as grounding-type bonding bushing or bonding bushing.
C	
Cabinet	An enclosure designed either for surface mounting or flush mounting that is provided with a frame, mat, or trim in which a swinging door or doors are, or can be, supported.
Cable	A fabricated assembly of one or more conductors in a single outer insulation. Types include axial, armored, and shielded.

Cable, AC	A fabricated assembly of insulated conductors in a flexible metallic enclosure. Type armored-cable (AC) cable is not the same as DEB cable.
Cable, Axial	Cable where all conductors are oriented on a single axis, such as coaxial, biaxial, and tri-axial cables.
Cable, Direct Buried	Cable with construction suitable for use in direct buried, underground installations without any form of conduit. Type direct buried cable is not the same as DEB cable.
Cable, Direct Earth Burial (DEB)	Cable with a ferrous shield designed to provide both physical and electromagnetic protection to the conductors.
Cable, MC	Metal-Clad Cable, Type MC. A factory assembly of one or more insulated circuit conductors with or without optical fiber members enclosed in an armor of interlocking metal tape, or a smooth or corrugated metallic sheath. See NEC. Note: For the purpose of this standard, MC cable is only permitted when installed in accordance with FAA-C-1217.
Cable, Shielded	Cable with a metalized or braid shield to improve resistance to electromagnetic interference (EMI).
Case	A protective housing for a unit or piece of electrical or electronic equipment.
Chassis	The metal structure that supports the electrical or electronic components which make up the unit or system.
Conductor, Bare	An electrical conductor that has no covering or electrical insulation.
Conductor, Insulated	An electrical conductor encased within material of composition and thickness recognized by the NEC as electrical insulation.
Conductor, Lightning Bonding (Secondary)	An electrical conductor used to bond a metal object, within the zone of protection and subject to currents induced by lightning strikes, to the lightning protection system.
Conductor, Lightning Down	The down conductor serves as the path to the EES from the roof system of air terminals and roof conductors or from an overhead ground wire.
Conductor, Lightning Main	Conductors intended to carry lightning currents between air terminals and the EES. These can be conductors interconnecting air terminals on the roof, conductors connecting a metal object on or above the roof level that is subject to a direct lightning strike to the lightning protection system, or the down conductor.
Conductor, Lightning Roof	Roof conductors interconnecting all air terminals to form a two-way path to the EES from the base of each air terminal.
E	
Earth Electrode System (EES)	A network of electrically interconnected grounding systems such as ground rods, ground plates, ground mats, incidental electrodes including metallic piping and tanks, or ground grids installed below grade to establish a low resistance contact with earth.
Electromagnetic Interference (EMI)	Any emitted, radiated, conducted, or induced voltage that degrades, obstructs, or interrupts the required performance of electronic equipment.

Electronic Multipoint Ground System (MPG)	An electrically continuous network consisting of interconnected ground plates, equipment racks, cabinets, conduit junction boxes, raceways, duct work, pipes, copper grid system, building framing steel, and other non-current-carrying metal elements. It includes conductors, jumpers, and straps that connect individual electronic equipment components to the signal reference structure (SRS).
Electronic Single Point Ground System (SPG)	A discreet signal reference network that provides a single point of reference in the facility for electronic equipment which require single point grounding. It consists of conductors, plates, and equipment terminals, all of which are isolated from any other grounding system except at the main ground plate.
Enclosed Cable Tray	A cable tray with steel/aluminum sides and bottom with a steel/aluminum cover or lid.
Equipment	A general term including materials such as fittings, devices, appliances, fixtures, apparatus, and machines, used in conjunction with an electrical installation.
Equipment Areas	Areas that house electronic equipment used to support NAS operations, such as electronic equipment rooms, telephone company (TELCO) rooms, Very High Frequency Omni Directional Range (VORs), and Radars.
Equipment Grounding Conductor (EGC)	The conductive path installed to connect normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both. For FAA purposes, the EGC is to be green-insulated, solid or stranded, copper wire.
F	
Ferrous Conduit	Conduits composed of or containing iron, which are used to provide magnetic shielding, such as Rigid Galvanized Steel Conduit (RGS) or thick walled threaded conduit (NEC Rigid Metal Conduit-RMC). Note: For the purpose of this standard, Electrical Metallic Tubing (EMT), Intermediate Metal Conduit (IMC), and conduits made from silicon bronze and stainless steel are not adequate for magnetic shielding protection.
Fitting, High Compression	See "Pressure Connector Terminations."
G	
Ground	A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to a conducting body that serves in place of the earth.
Ground Dissipation Plate Design	Ground plate, refer to Figure 6.
Grounded	Connected to earth via a path of sufficiently low impedance and having sufficient current carrying capacity, such that fault current cannot build up voltage potentials that are hazardous to personnel.
Grounded Conductor	A system or circuit conductor that is intentionally grounded at the SDM or at the source of a separately derived system. This grounded conductor is the neutral conductor for the power system.
Grounding Conductor	A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding Electrode	Copper rod, plate, or wire embedded in the ground for the specific purpose of dissipating electric energy to the earth. Also referred to as the Grounding Electrode System.
Grounding Electrode Conductor (GEC)	A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.
H	
High Frequency	All electrical signals at frequencies greater than 100 kHz, and pulse and digital signals with rise and fall times of less than 10 μs.
High Transient Ground Plate	Entry or termination ground plate for connection of axial cable surge protection equipment and termination of cable shields, waveguides, conduits, and cable jackets. See Bulkhead Ground Plate.
Horizontal Transitions	Architectural term used to describe horizontal elements in a vertical structure, such as floor levels and stair landings.
Hydraulically Crimped Termination	Conductor termination using a hydraulic crimping tool that applies a 12-ton minimum compression force, using concentrically or circumferentially matching dies to form the connection.
I	
Inaccessible Location	A condition where gaining access to a system or part thereof requires significant effort, cost, or risk to personnel safety. Examples of such locations include below grade, behind walls and obstructions, or enclosed or concealed spaces that impede visual inspection.
L	
Landline	Any conductor, line, or cable installed externally above or below grade to interconnect electronic equipment in different facility structures or to interconnect externally mounted electronic equipment.
Low Frequency	Voltages and currents, whether signal, control, or power, up to and including 100 kHz. Pulse and digital signals with rise and fall times of 10 μs or greater are considered to be low-frequency signals.
M	
Main Service Disconnect	A switch, fused switch, or circuit breaker that disconnects the main ac power service, generally utility power source, from a facility, located at the service disconnecting means (SDM).
O	
Office of Primary Responsibility (OPR)	The authority assigned to maintain and interpret this standard.
Operational Areas	Areas used to provide NAS support such as Instrument Flight Rules (IFR) rooms, Air Route Traffic Control Center (ARTCC) control rooms, ATCT tower cabs, operations control centers, and TRACON control rooms.
P	
Pressure Connector Terminations	Conductor termination using a mechanically bolted pressure connection.

R	
Rack	A metal frame in which one or more electronic equipment units are mounted.
Rigid Metal Conduit (RMC), Rigid Galvanized Steel Conduit (RGS)	A threaded raceway of circular cross-section designed for the physical protection, routing, and shielding of conductors and cables.
S	
Service Disconnecting Means (SDM)	Refer to the NEC definition for Service Point location.
Shield	A housing, shield, or cover that substantially reduces the coupling of electric and magnetic fields into or out of circuits or prevents accidental contact of objects or persons with parts or components operating at hazardous voltage levels.
Signal	Any electromagnetic transmission of information or control function. A signal can be analog, digital data, or a control function such as a relay closure.
Signal Reference Structure (SRS) System	The conductive terminal, wire, bus, plane, or network that serves as the relative zero potential for all associated electronic signals. Signal Reference Structures are required at locations or areas containing NAS electronic equipment.
Structure	Any fixed or transportable building, shelter, tower, mast, or other load-bearing system that is intended to house electrical or electronic equipment or otherwise support or function as an integral element of the air traffic control system.
Surface Resistivity	Surface Resistivity can be described as follows: For electric current flowing across a surface, the ratio of DC voltage drop per unit length to the surface current per unit width. In effect, the surface resistivity is the resistance between two opposite sides of a square and is independent of the size of the square or its dimensional units. Surface resistivity is expressed in ohms/square. See ESD ADV1.0 Glossary of Terms.
Surge	A short-term disturbance characterized by a sharp, brief discontinuity of a waveform. May be of either polarity and may be additive to, or subtractive from, the normal waveform.
Surge Protective Device (SPD)	A device intended to limit surge voltages on equipment by diverting or limiting surge current and is capable of repeating these functions as specified. SPDs are also commonly referred to as Transient Voltage Surge Suppressors (TVSS) or secondary surge arresters.
Susceptibility Level	The transient level on signal, control, or data lines that causes damage, degradation, or upset to electronic circuitry connected to the line.
T	
Transient	See Surge.
Transient Suppressor	Components, devices, or circuits designed for the purpose of attenuating, absorbing, and suppressing conducted transient and surge energy to protect facility equipment.
Z	
Zone of Protection	The space adjacent to a lightning protection system that has a reduced probability of receiving a direct lightning strike.

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4 GENERAL REQUIREMENTS

4.1 Introduction

This chapter covers the common requirements and standard practice for the overall design, installation, construction, and evaluation of the following grounding systems in FAA facilities:

a. Bonding Requirements

b. Lightning Protection System Requirements

c. Earth Electrode System (EES) Requirements

d. National Electrical Code (NEC) Power Distribution System Grounding Compliance

e. Surge Protective Device (SPD) Requirements

f. Grounding and Bonding Requirements for NAS Electronic Equipment Areas

g. Shielding Requirements

h. Electrostatic Discharge (ESD) Requirements

4.2 Bonding Requirements

The method of bonding, for the purpose of achieving electrical continuity, shall be in accordance with 4.2.1 through 4.2.5.

4.2.1 General

This section covers the following topics:

a. Dissimilar Metals Compatibility Requirements

b. Methods of Bonding

c. Bonding Connection Installation Requirements

d. Hardware for Bonding Jumpers and Straps

4.2.1.1 [A1] Resistance of Bonds

Unless otherwise specified in this standard, bonds shall have a maximum direct current (dc) resistance of 1 mΩ when measured between the bonded components with a four-terminal milliohmmeter.

4.2.2 Dissimilar Metals

Bonding connections and associated fastener hardware for grounding system conductors shall comply with Table 1**.**

Table 1. Mechanical Bonds Between Dissimilar Metals

METAL	Copper, solid or plate	Brass and bronze	Stainless Steel	Tin-plate; tin-lead solder	Aluminum, wrought alloys of the 2000 Series	Iron, wrought, gray or malleable, plain carbon and low alloy steels	Aluminum, wrought alloys other than 2000 Series aluminum, cast alloys of the silicon type	Aluminum, cast alloys other than silicon type, plated and chromate	Galvanized steel	Zinc, wrought; zinc-base die-casting alloys; zinc plated
Copper, solid or plate	●●●	●●●	●●	●	●	●	No	No	No	No
Brass and bronze	●●●	●●●	●●	●●	●	●	●	No	No	No
Stainless Steel	●●	●●	●●●	●●●	●●●	●●	●	●	No	No
Tin-plate; tin-lead solder	●	●●	●●●	●●●	●●●	●●	●●	●	No	No
Aluminum, wrought alloys of the 2000 Series	●	●	●●●	●●●	●●●	●●●	●●●	●●	●	●
Iron, wrought, gray or malleable, plain carbon and low alloy steels	●	●	●●	●●	●●●	●●●	●●●	●●●	●	●
Aluminum, wrought alloys other than 2000 Series aluminum, cast alloys of the silicon type	No	●	●	●●	●●●	●●●	●●●	●●●	●	●
Aluminum, cast alloys other than silicon type, plated and chromate	No	No	●	●	●●	●●●	●●●	●●●	●●	●
Galvanized steel	No	No	No	No	●	●	●	●●	●●●	●●●
Zinc, wrought; zinc-based die-casting alloys; zinc plated	No	No	No	No	●	●	●	●	●●●	●●●

LEGEND: Four Basic Categories of Possible Metal Interfaces

No	Not suitable. This interface is highly likely to result in significant corrosion.
●	Suitable for indoor environments where temperature and humidity are controlled (non-condensing environment).
●●	Suitable for all indoor environment.
●●●	Suitable for all environments.

4.2.3 Methods of Bonding

Direct bonding techniques include:

a. Exothermic Welds. Exothermic welds are permitted for any type of bond connection specified herein.

b. Hydraulically Crimped Terminations. Crimped terminations are permitted as an alternative technique to facilitate installation of connections in permanently concealed or inaccessible locations.

c. Welded Assemblies. Metal fabrication assembly process constructed by welding the joints between the individual components.

d. Mechanical Connections. Electrical bond connections constructed with bolted assemblies.

e. Brazing and Soldering. Metal-joining process formed by brazing or soldering a filler alloy metal is not permitted for bond connections.

f. Silver Soldering - Only Applicable for NAS Electronic Equipment. To improve conductivity, silver soft soldering material may be applied for the bonding of enclosure shielding joints already secured with mechanical fasteners. Mechanical fasteners shall be attached prior to application of solder to prevent cold solder joints. Soft soldering techniques are not permitted as a method for providing mechanical restraint.

4.2.3.1 Exothermic Welds

Exothermic welded connections shall be provided for the following applications:

a. Permanent Bonding. Permanent bonding of copper conductors to metal assemblies or building steel.

b. Underground or Buried Locations.

c. Exposed Exterior Locations. Any exposed location where an exothermic weld connection is possible.

d. Permanently Concealed Locations. Locations where the connection will be permanently concealed after completion of fabrication or building construction process.

e. Inaccessible Locations. Locations rendered inaccessible due to a building feature or other physical constraint that restricts routine access necessary to perform maintenance and visual inspection.

Exception. *Where exothermic welds are not possible due to dissimilar materials, incompatible shapes, voiding of a manufactured finish warranty, or in hazardous locations, such as near fuel tanks or other combustible material, provide UL listed hydraulically crimped or mechanical connections.*

4.2.3.1.1 Exothermic Welds – Installation within Existing Facilities

The following measures shall be taken in the installation of exothermic welds within existing facilities:

a. Where combustion from the use of a standard exothermic weld process would result in problems within the facility, a smokeless type exothermic weld process shall be provided.

b. After completing the welding process, to prevent corrosion, remove or neutralize residual fluxes between components.

4.2.3.2 Hydraulically Crimped Terminations

A UL 467 and UL 96 listed irreversible compression type bonding connection is permitted for use within concealed and inaccessible locations.

a. Bonding Conductors. Bonding conductors shall be wire size 6 AWG or larger.

b. Hydraulic Compression Tool System. Hydraulic compression tool system shall be capable of producing a 12-ton minimum force applied with a tool using matching dies.

4.2.3.3 Welded Assemblies

Individual components of a welded assembly shall not require additional bonds between components if the dc resistance between individual components is less than 1 mΩ.

4.2.3.4 Mechanical Bolted Bond Connections

Mechanical bolted bond connections shall be prepared and completed in accordance with the installation conditions and requirements provided herein.

4.2.3.4.1 [A2] Coupling of Dissimilar Metals

Compression bonding with bolts and clamps shall comply with Table 1. When dissimilar base metals form couples that are not permitted per Table 1, the metals shall be coated, plated, or otherwise protected with a conductive finish.

4.2.3.4.2 Bolted Connections

Bonding bolts shall be used primarily as mechanical fasteners to hold electrical bonding components in place. Tighten bolts sufficiently to achieve adequate contact pressures for effective bonding, but do not overtighten them to the extent that deformation of bond members occurs. To prevent loosening of the connection, provide disc springs for connections using bolts 1/4-in. diameter and greater.

a. Torque Requirements. Bolted connections 1/4-in. diameter and greater shall conform to the torque requirements in Table 2.

b. Bolts, Nuts and Washers. Bolted connections in corrosive, damp, or wet locations, 1/4-in. diameter and greater, shall utilize stainless steel type 18-8 bolts, nuts, and load distribution washers. All other locations shall use corrosion-inhibited SAE Standard J429 Grade 5 nuts and bolts. Load distribution washers shall comply with ANSI B18.22.1 for stainless steel washers, Wide Series, Type B.

c. Assembly. Bolted connections 1/4-in. diameter and greater shall be assembled in the order shown in Figure 1. Additional load distribution washers, if used, shall be positioned directly beneath the bolt head. Disc springs shall be between the nut and the load distribution washer. Washers shall not be placed between bonded members. Load distribution washers shall be Wide Series, Type B.

d. Termination Lugs. Provide 2-hole termination lugs for connections to ground plates. Provide 2-hole termination lug connections to equipment metal members for conductors size 6 AWG and larger. If the equipment metal members do not allow modification for installation of 2-hole lug terminations, then 1-hole termination lug are permitted.

4.2.3.4.2.1 Sheet Metal Screws

Sheet metal screws shall not be used to provide an electrical bond.

4.2.3.4.2.2 Self-drilling and Self-tapping Screw Fasteners

Self-drilling and self-tapping metal screws are permitted to make a physical connection between metal back panels within equipment cabinet/enclosures when access to the opposite side of the bond is not available using other bonding methods.

4.2.3.4.3 Riveting

Rivets shall be employed solely as mechanical fasteners to hold multiple smooth, clean metal surfaces together or to provide a mechanical load-bearing capability to a soldered bond.

Table 2. Connection Torque Requirements for Bolted Bonds

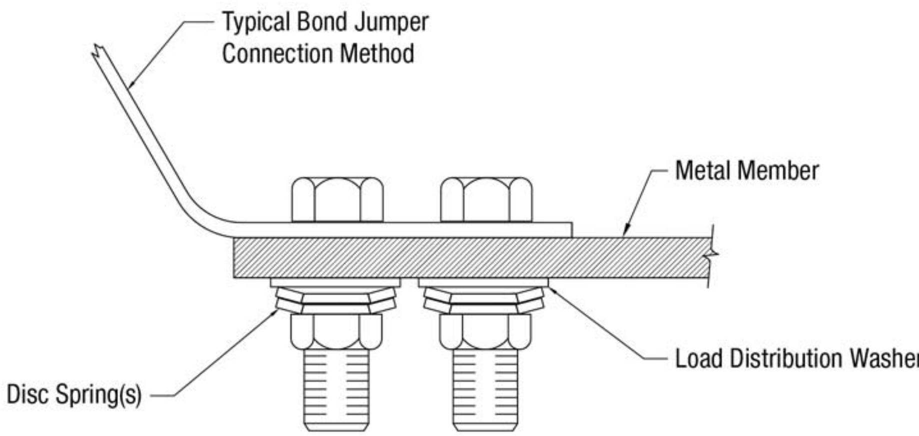
Bolt Specification for Stainless Steel 301 Type SS 18-8						
Bolt diam. (in.)	**Threads per inch**	**Torque (ft-lbs) SS 18-8**	**Bolt Clamp Load (lbs.)**	**Flat Load (lbs.)**	**Washers Required** (see note 2)	**Solon Part Number** (see note 1)
1/4	20	6	1,510	600	3	4-L-42-301
5/16	18	11	2,120	1,000	3	5-L-52-301
3/8	16	19	3,150	2,100	2	6-M-80-301
7/16	14	31	4,300	N/A	N/A	N/A
1/2	13	43	5,170	3,300	2	8-L-90-301
9/16	12	56	6,070	2,800	3	9-L-89-301
5/8	11	92	8,880	5,500	2	10-20-125-301
3/4	10	127	10,200	13,800	1	12-EH-168-177
7/8	9	194	13,310	14,400	1	14-H-168-177
1	8	286	17,200	14,200	2	16-H-187-177
Bolt Specification for SAE J429 Type Grade 5						
Bolt diam. (in.)	**Threads per inch**	**Torque (ft-lbs) Grade 5**	**Bolt Clamp Load (lbs.)**	**Flat Load (lbs.)**	**Washers Required** (see note 2)	**Rolex-Fastenal Part Number** (see note 1)
1/4	20	10	2,500	1,390	2	0124030
5/16	18	21	4,000	5,345	1	0124033
3/8	16	34	5,500	8,000	1	0124035
7/16	14	55	7,500	N/A	N/A	N/A
1/2	13	83	10,000	9,900	2	0124037
9/16	12	117	12,500	12,000	2	0124039
5/8	11	167	16,000	13,000	2	0124041
3/4	10	288	23,000	31,000	1	0124043
7/8	9	452	31,000	40,276	1	0124044
1	8	567	40,000	46,000	1	0124046

Notes:

1. Other manufacturers of disc spring washers of equal or better performance are permissible. Use bolt assembly manufacturer’s recommended torque values.
2. The sum of the individual disc washer flat load ratings shall exceed the listed bolt clamp load. The number of washers required is calculated by the following formula:

$$B_{\text{Bolt Clamp Load}} < W_{\text{Number of Washers}} \times F_{\text{Washer Flat Load}}$$

For example, a 1/4-in. stainless steel bolted connection requires minimum 1,510 lbs clamp load, therefore, 3 disc washers will be needed.



Notes:

1. Remove all paint on the entire bonding area of the metal member.
2. Stack disc spring washers to obtain required amount per Table 2.
3. Provide 2-hole termination lugs for connections to ground plates.

Figure 1. Order of Assembly for Bolted Connections

4.2.4 Bonding Connections – Installation Requirements

Bonding connections shall be prepared and completed in accordance with the installation conditions and requirements provided herein.

4.2.4.1 Surface Preparation

Bonding surfaces shall be cleaned thoroughly and free of dirt, dust, grease, oxides, nonconductive films, and foreign material. Paint and other coatings at the location shall be removed to expose the base metal.

a. Surface Area To Be Cleaned. Clean mating surfaces at least 1/4-in. beyond each side of the smaller bonded area.

b. Clad Metals. Clean clad metal to a bright, shiny, smooth surface without penetrating the cladding. Wipe the cleaned area with solvent and allow the surface to air dry before completing the bond.

c. Aluminum Alloys. To create a bright finish after cleaning, apply a conductive coating with paint or resin finish to aluminum mating surfaces.

4.2.4.2 Completion of Bonding Connection

Clean surfaces with a solvent suitable for electrical work immediately prior to assembly. Mating surfaces shall be joined within 2 hours after cleaning if an intentional protective coating has been removed from the metal surface. If delays beyond 2 hours are necessary in corrosive environments, then the cleaned surfaces shall be protected with an appropriate coating that shall be removed prior to completion of the bond connection.

a. Refinishing of Bond. Areas around the bond connection shall be restored to match the original finish, unless not feasible.

b. Surface Plating or Treatments. Surface plating or treatments may be applied to the connection to improve abrasion resistance and corrosion protection, provided the treatment material enhances bond conductivity. Silver and other easily tarnished metals shall not be used to plate bonded surfaces, except where use of other metals may result in an unacceptable increase in surface contact resistance. In such cases, protect plating material by sealing exposed surfaces of the completed connection from the atmosphere.

4.2.4.3 Sealing and Finish Treatments for Bonding Connections

All bonds shall be protected against weather, corrosive atmospheres, vibration, and mechanical damage. Under dry conditions, apply a compatible corrosion preventive or sealant within 24 hours of assembly of the bond materials. Under conditions exceeding 60 percent humidity, seal the bond with a compatible corrosion preventive or sealant within 1 hour of joining.

Exterior bonds shall be protected against corrosion. Interior bonds exposed to moisture or high humidity shall be protected against corrosion.

a. Sealing Treatment for Corrosion Protection. Corrosion protection shall be provided by sealing the bond connection with a moistureproof paint conforming to FAA-STD-012 or with a silicone or petroleum based sealant to prevent moisture from reaching the bonding area. Bonds protected by conductive finishes such as alodine and iridite shall not require painting to meet the requirements of this standard.

b. Compression Bonds in Climatically Protected Areas. Sealing is not required for compression bonds between copper conductors or compatible aluminum alloys that are located in readily accessible areas that are not exposed to moisture, corrosive fumes, or excessive dust.

c. Painted Finishes. If a paint finish treatment is required on the final assembly, then the bond shall be sealed in accordance with the manufacturer's recommendation. To ensure the bond is completely sealed against moisture, a waterproof type of paint or primer shall be used if the recommended finish treatment is not waterproof.

4.2.5 Bonding Connections – Hardware for Bonding Jumpers and Straps

Bonding jumpers and straps shall be installed in accordance with the requirements provided herein.

4.2.5.1 Installation of Bonding Jumpers

Bonding jumpers shall be insulated conductors, except as noted herein.

Bare conductors shall be used for the following applications:

a. Raised access floor installations.

b. Jumpers for structural steel or rebar connected to the EES, lightning protection systems, and plenums or environmental air spaces.

c. Jumpers too short to be insulated or where required by NEC.

4.2.5.2 Installation of Bonding Straps

Bonding straps for bonding of electronic equipment shall be as short as possible. Herein, bonding straps are expected to be bare.

Bonding straps shall conform to the following:

a. Bonding straps shall be attached to the integral structural frame portion of the cabinet/enclosure rather than through adjacent parts to achieve optimal electrical connection.

b. Bonding straps shall be installed so that the electrical bond is not affected by motion or vibration.

c. Bonding straps shall be installed wherever possible in areas accessible for maintenance and inspection.

d. Bonding straps shall be installed to allow movement of the components being bonded or other adjacent components intended to move as part of normal functional operation.

e. Two or more bonding straps shall not be connected in series to provide a single bonding path.

f. The method of installation and point of attachment of bonding straps shall not weaken the components to which they are attached.

g. Bonding straps shall not be compression fastened through nonmetallic material.

h. Bonding installed across shock mounts or other suspension/support devices shall not restrict the performance of the mounting device. Bonding connections shall be capable of withstanding anticipated motion and vibration of supports without suffering metal fatigue, loosening of ground connections, or other degradation.

4.2.5.3 Fastener Hardware

Fastener materials for attachment of bonding straps and jumpers to structures shall conform to materials listed in Table 1.

4.2.5.4 Temporary Bonding Connections

Alligator clips or spring-loaded clamping products are permitted only for the purpose of establishing a temporary bond connection while performing repair work on equipment or facility wiring.

4.3 Lightning Protection System Requirements

4.3.1 General

The purpose of the lightning protection system is to provide preferred paths for lightning discharges to enter or leave the earth without causing damage to facility or equipment or injury to personnel. The essential components of a lightning protection system are air terminals and roof and down conductors connecting to the EES, the EES, and SPDs. These components act together as a system to dissipate lightning energy. The lightning protection system shall meet or exceed the requirements of FAA standards and orders as specified herein and the following:

a. Standard for the Installation of Lightning Protection Systems (NFPA 780)

b. Installation Requirements for Lightning Protection Systems (UL 96A)

The risk assessment guide in NFPA 780 indicates that many NAS facilities have a high risk index. Accordingly, lightning protection requirements that exceed the minimum requirements of NFPA 780 are specified herein. Inclusion of a UL Master label is not sufficient to indicate compliance with this standard.

a. ATCT Special Requirements. See section 5.2 for Airport Traffic Control Tower (ATCT) special requirements.

b. Other Special Conditions. See section 5.3 for other lightning protection system special conditions.

4.3.2 Lightning Protection System – Components

Products shall be UL listed and labeled with the UL certification mark in accordance with UL requirements. All equipment shall be new and of adequate design and construction to suit the application in accordance with UL 96A requirements. Provide copper or tinned copper cable materials. Aluminum cables shall only be used on aluminum and galvanized surfaces. Bimetallic connectors shall be used for interconnecting copper and aluminum conductors. Dissimilar materials shall conform to the bonding requirements of paragraph 4.2.2.

4.3.3 Lightning Protection System – Material Class Requirements

The FAA has opted to exceed minimum NFPA 780 cable sizing requirements. Provide Class II or larger rated materials, as specified in NFPA 780, for the following:

a. Air Terminals

b. Main and Down Conductors

c. Bonding Conductors

4.3.4 Lightning Protection for NAS Facilities Buildings and Structures

Lightning protection shall be provided for buildings and structures, or parts thereof that are not within the zone of protection provided by another building, higher part of a building, an antenna, or a tower. The zone of protection scheme for all structures shall be as defined in NFPA 780.

4.3.4.1 Number of External Down Conductors for Buildings

The number of down conductors shall be based on both the building height and perimeter.

a. Buildings and Structures Less Than 60 ft High Above Grade. These buildings and structures measured to the highest point of the building or structure shall have at least two down conductors.

b. Buildings and Structures More Than 60 ft High. See section 5.2.2.

c. Buildings and Structures with Perimeters in Excess of 250 ft. These buildings and structures shall have one additional down conductor for each 100 ft of perimeter distance or part thereof. Down conductors shall be as widely separated as possible, e.g., at diagonally opposite corners on square or rectangular buildings.

4.3.4.2 Metal Parts of Buildings

Building steel, metal roofing, metal supporting structures, concrete reinforcing steel, siding, eave troughs, down spouts, ladders, duct, and similar metal parts shall not be used as substitutes for roof or down conductors. A lightning protection system shall be applied to the metal roof and metal siding of a metal clad building in the same manner as on a building without metal covering. Building metal parts shall be bonded in accordance with paragraph 4.3.8.

Exception. *See paragraph 5.2.2.3*b *for ATCT lightning protection system design requirements.*

4.3.4.3 Roof-Mounted Antenna Masts

Unless it is a radiating or receiving part of the antenna, the metallic mast of a roof-mounted antenna shall be bonded to the nearest main roof conductor or down conductor.

a. If a main roof conductor or down conductor is not available where an antenna is installed on top of an ATCT, then bond the antenna mast to building steel in lieu of the EES. Reinforcing bars shall not be used in lieu of building steel.

b. If an antenna is installed on top of a building or base building, and the path is longer than a tenth of the difference between building steel and the EES (i.e. building steel is 5 feet away and the EES is more than 50 feet away), then bond the antenna mast to building steel. Reinforcing bars shall not be used in lieu of building steel.

4.3.5 Lightning Protection System - Conductor Routing

Down conductors shall follow the most direct downward path to earth. Main and bonding conductors shall maintain a downward or horizontal course, and are permitted to rise at no greater than a 1 to 4 slope.

a. Conductor Bends. Down conductors shall be installed without any sharp bends or kinks. No bend in a main and bonding conductor shall form an included angle of less than 90 degrees, nor shall it have a bend sweep radius of less than 8 in.

b. Conductor Connections. T-style and cross-over cable-to-cable connections between main conductors shall be in accordance with Figure 2.

c. Conductor Routing. Conductors shall be routed outside of structures and not penetrate structural cladding except as indicated in 5.2.2.3b. Conductors shall be routed 6 ft or more from power or signal conductors. If this clearance cannot be met, the power and signal conductors shall be routed in ferrous RGS conduit or enclosed ferrous cable tray.

d. Main Conductors. Main conductors shall be permitted to pass through elements of the building structure, e.g., parapets, eaves, walkways, walls, where necessary to maintain horizontal or downward course. Provide a 2-in., Schedule 80 rigid PVC conduit sleeve, or UL listed through-connector fitting at penetrations. When the conductor penetrates a metallic structure of any thickness, the conductor shall be bonded to the metallic structure. Conductors are permitted to pass through metal gratings or plates without a conduit sleeve; however, the conductor shall be bonded to the metallic structure.

4.3.5.1 Main and Down Conductor Terminations to EES

Conductor terminations to the EES shall be exothermically welded to a 4/0 AWG copper conductor prior to entering the ground at not less than 18 in. above grade. The 4/0 AWG copper conductor shall be bonded directly to a ground rod or electrode conductor in the EES. Exothermic weld connections to the EES shall be in accordance with Figure 3.

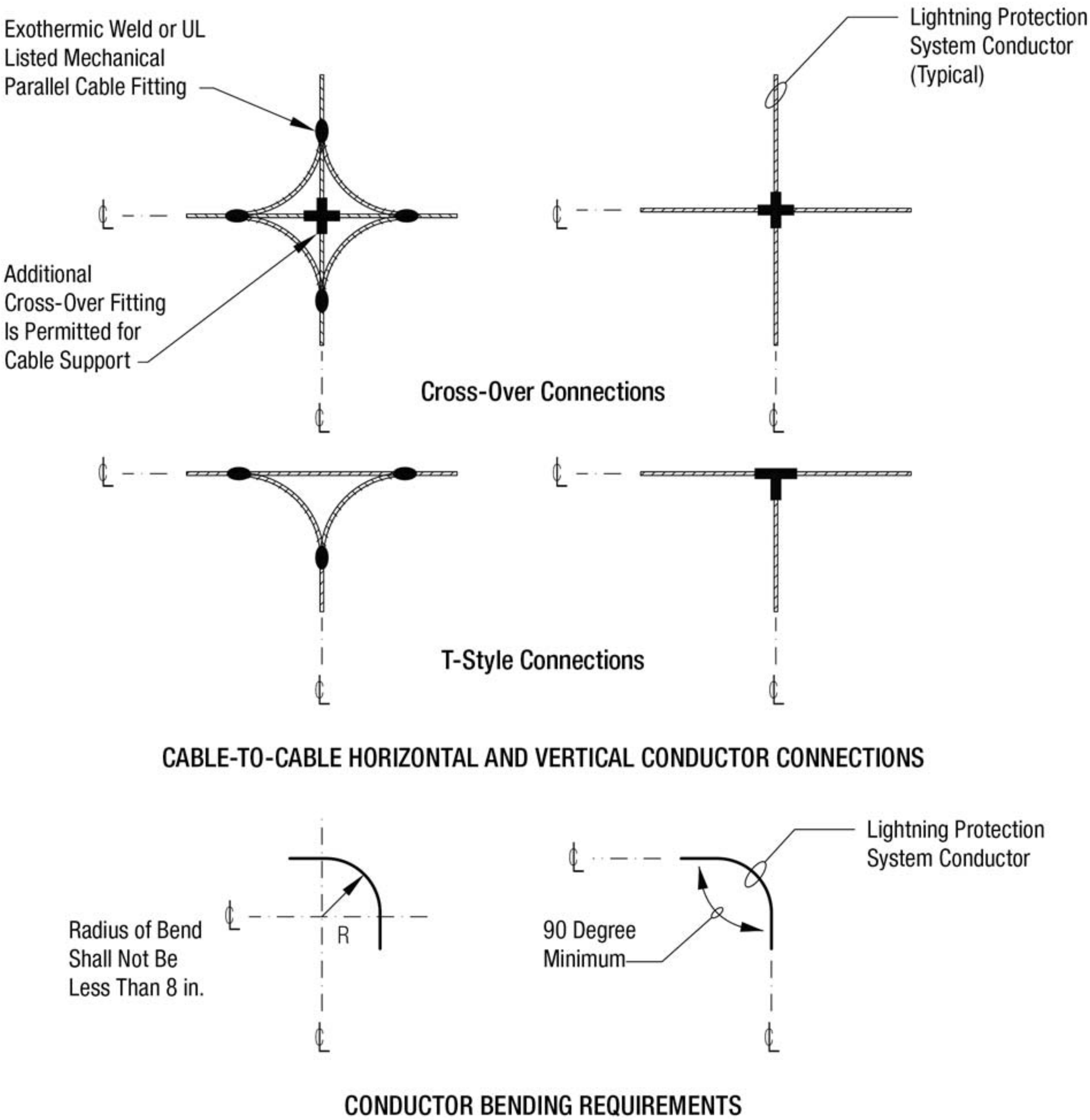
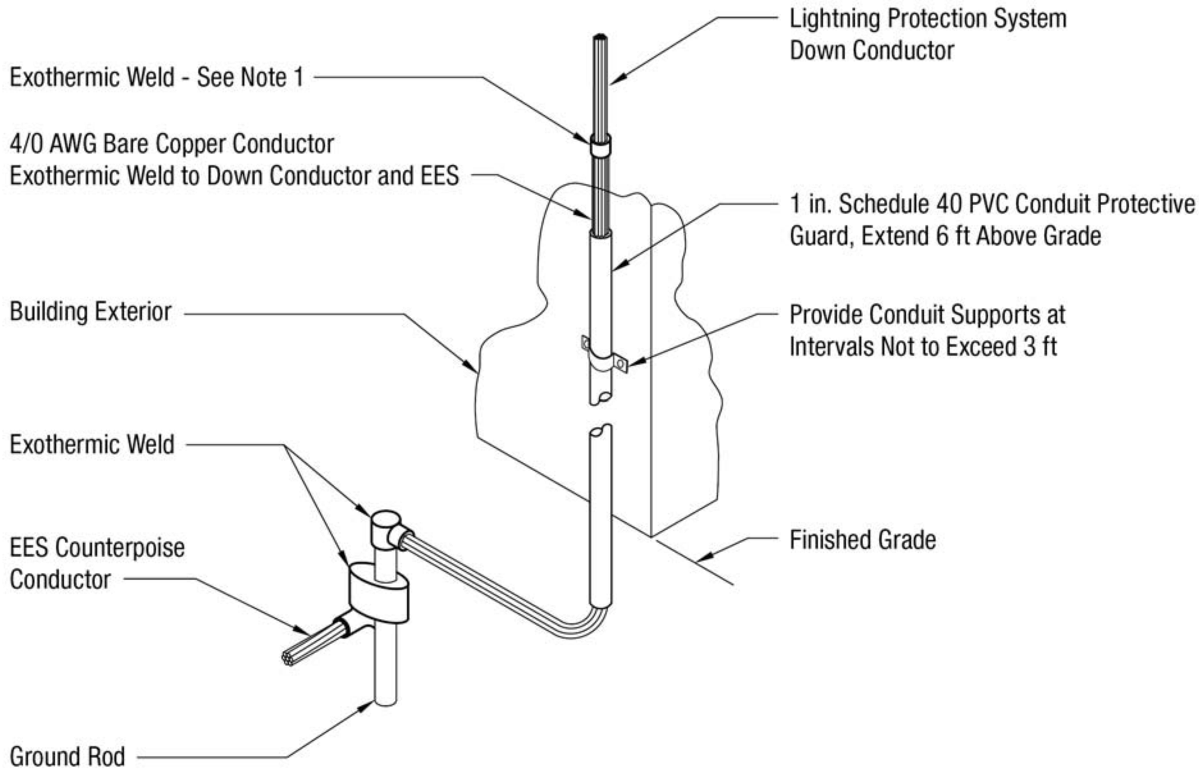


Figure 2. Lightning Protection System Main Conductor Connections – Illustrative Example



Note:

1. Locate exothermic weld above the conduit guard to ensure connection is available for visual inspection. When installation of the connection is not possible at top of conduit guard, locate the exothermic weld at least 18 in. above finished grade and provide guard system with pull box and removable cover that will permit visual inspection of the weld connection.

Figure 3. Main and Down Conductor Termination to EES – Illustrative Example

4.3.6 Lightning Protection System - Air Terminals

Air terminals shall be solid copper, bronze, or aluminum. Air terminals shall be stainless steel in areas of high potential for corrosion. Copper air terminals shall be allowed to have nickel plating. Air terminals shall be 12-in. high minimum, with a diameter of at least 1/2-in. for copper and 5/8-in. for aluminum, and have sharp, blunt or approved protective style tip. Air terminals shall be located and installed in accordance with NFPA 780 and UL 96A, and as required herein. Closer spacing is permitted for unique geometries. Air terminals shall extend at least 10-in. above the object or area it is to protect.

Air terminals located near working or walking surfaces may present an impalement hazard to personnel. The impalement protection design may be accomplished through use of air terminal selection, air terminal mounting type, mounting height, or a combination thereof. If mounting height is selected to mitigate the impalement hazard, the top of the air terminal shall not be less than 5-ft above the adjacent walking surface. If it is not feasible to install the air terminal on the object, locate air terminals next to the object to achieve this requirement, and bond the metallic object to the lightning protection system.

4.3.6.1 Mast Poles Used For Air Terminal Installation

Air terminals installed on mast poles shall be at least 2 ft tall and extend a minimum of 10 in. above the top of the mast pole. Provide a down conductor installed on the exterior of the mast pole. Air terminal and down conductor shall be fastened to the pole in accordance with NFPA 780. Connect air terminal to the nearest main roof conductor or down conductor. If a roof or down conductor is not available, bond directly to the EES.

4.3.7 Lightning Protection System - Hardware

Lightning protection system hardware and installation shall be prepared and completed in accordance with the installation conditions and requirements provided herein.

4.3.7.1 Fastener Hardware

Provide conductor fasteners at intervals in accordance with NFPA 780. Provide fastener material using the same base material as the system conductor, or a material equally resistant to corrosion as the system conductor.

a. Plastic, Galvanized, or Plated Materials. Not permitted.

b. Fasteners. Where fasteners are part of a bonding connection component, the bonding surface shall be prepared and protected in accordance with paragraph 4.2.4. Cable holders that do not have mechanical support such as products with fold-over or break-away tabs shall not be used.

4.3.7.2 Terminations and Fittings

The preferred method for conductor connections and terminations is by exothermic welding. Where mechanical bolted pressure termination fittings are used the bonding devices, conductor splices, conductor terminations, and connectors shall be compatible with the installed conductor. Provide stainless steel, copper, bronze, or aluminum termination materials in accordance with the following:

a. Materials. Fitting material shall be suitable for use with the system conductor.

b. Straight and 90 Degree Through-Connectors. UL listed straight and 90 degree through-connectors are permitted to facilitate horizontal and vertical routing of system conductors.

4.3.7.3 Conductor Protective Guards

Provide protective guards for system down conductors located in or next to driveways, walkways, or other areas where they are subject to damage or displacement.

a. Nonmetallic Guards. Provide nonmetallic conductor guards, schedule 40 polyvinyl chloride (PVC) conduit or equivalent.

b. Guard Installation. Install guard from 1 ft below grade level extending to 6 ft above grade. When the roof or roof soffit construction is within 2 ft of the guard, the protective guard may be lowered to facilitate termination of the down conductor.

Exception. *Metal guards are permitted in lieu of nonmetallic material; however, metal guards shall be bonded to the down conductors at both ends of the guard. Provide bonding conductor size equal to the down conductor size.*

4.3.8 Lightning Protection System – Bonding Connections

Bonding connections shall be prepared and completed in accordance with the installation conditions and requirements provided herein. Provide exothermic welds for conductor connections to the EES.

4.3.8.1 Metallic Bodies Subject to Direct Lightning Strikes

Metallic bodies and assemblies that protrude beyond the zone of protection provided by the installed air terminals are subject to direct lightning strikes. This includes but is not limited to roof drains, gutters, vents, canopies, electrical raceway and fixtures, pipes, exhaust fans, metal cooling towers, HVAC units, ladders, railings, antennas, structures with metal louvers, etc.

Provide lightning protection for metallic bodies and assemblies for the following conditions:

a. Electrically Continuous Assemblies.

   1. Where metal thickness is 3/16 in. or greater, bond the assembly to the nearest lightning protection system main conductor. Provide fitting with bonding surface of at least 3 in.^{2}

   2. Where metal thickness is less than 3/16 in., install air terminals, main conductors, and fittings to provide at least two paths to ground from each air terminal device.

b. Not Electrically Continuous Assemblies. If the assembly consists of segmented parts and is not electrically continuous, then provide an additional main conductor interconnected to the nearest lightning protection system. Bond the individual metal parts. Provide at least two paths to ground.

4.3.8.2 Metallic Bodies Subject to Induced Charges

Metallic bodies that are subject to induced charges from lightning, including those in a zone of protection, shall be bonded to the lightning protection system in accordance with NFPA 780. This includes, but is not limited to, roof drains, vents, coping, flashing, gutters, downspouts, doors, door and window frames, balcony railing, conduits, and pipes, etc.

4.3.8.3 Metallic Bodies – Special Conditions

Metallic bodies located at grade or outside the lightning protection system's zone of protection may be bonded by direct connections to the EES.

4.3.8.3.1 Exhaust Stack Grounding

Fossil fuel exhaust stacks shall be bonded to the nearest lightning protection system main conductor or directly to the EES, using a bonding conductor of greater than or equal size as the main conductor. Provide exothermic weld or mechanical connection at exhaust stack, and exothermic weld at EES.

When the exhaust stack is located farther than 6 ft from a main conductor and, the exhaust stack shall be bonded directly to the EES.

4.3.8.3.2 Fuel and Oil Storage Tanks

Provide exothermic welds to bond tank vent piping and assemblies to the EES. Mechanical bonds may be used where required for dissimilar metals or component compatibility at the tank assembly. Bond tank vent piping and assemblies in accordance with following:

a. Above-Ground Nonpressurized Fuel and Oil Tank Vent Piping. Bond above-ground tank vent piping directly to the EES using a bonding conductor of greater than or equal size as the lightning protection system main conductor.

b. Above-Ground Tank Assemblies. Provide at least two easily accessible and widely separated grounding points for the tank assembly. Bond each grounding point directly to the EES using a 2/0 AWG conductor. Bond other metallic components, e.g., stairs, ladders, or skids, with a 2/0 AWG copper conductor.

c. Above Ground Pressurized Fuel Tanks. For pressurized fuel tanks, e.g., propane and compressed natural gas, provide at least one bond connection from tank mounting supports connected directly to the EES using a 2/0 AWG copper conductor.

d. Indoor Fuel and Oil Tank Vent Piping. Bond indoor mounted engine-generator day tank or other metallic fuel storage system vent piping mounted on the building exterior in accordance with NFPA 780.

e. Secondary Containment Systems. Secondary containment for fuel piping shall be bonded directly to the EES.

4.4 Earth Electrode System (EES)

4.4.1 General

An EES shall be installed at each facility to provide a common point of reference for all grounded systems at the facility. The EES establishes a low resistance to earth for lightning discharges, electrical and electronic equipment grounding, and surge/transient protection. The EES shall be capable of dissipating within the earth the energy of direct lightning strikes with no ensuing degradation to the system itself. The EES shall dissipate dc, ac, and radio frequency currents from equipment and facility grounding conductors.

4.4.2 [A3] Site Survey and Geotechnical Investigation

A subsurface geotechnical investigation shall be required to establish the design approach and parameters for new building construction to determine soil composition and resistivity characteristics. Information to be collected shall include location of rock formations, gravel deposits, soil types and classifications, and moisture content. The survey data shall be noted on a scaled drawing or sketch of the site, and documented in the Facility Reference Data File (FRDF). Soil resistivity testing shall be in accordance with FAA-HDBK-010.

4.4.3 EES – Design

The EES normally consists of driven ground rods, buried interconnecting conductors, and connections to underground metallic pipes, excluding gas lines and fuel tanks. The site survey and geotechnical investigation shall be used as the basis for the design of new buildings. The design objective for the EES resistance to earth shall be as low as possible, but shall not be greater than 10 **Ω**. Where "poor soil" conditions are encountered such as surface rock, shallow soils, permafrost, soils with low moisture, or high mineral content, then grounding enhancement methods listed in paragraph 4.4.5 shall be considered.

4.4.4 EES - Configuration

The EES shall consist of a continuous buried counterpoise conductor loop that extends around the entire perimeter of the facility or building structures. Provide ground rods interconnected along the counterpoise loop, spaced at least one ground rod length apart. Refer to FAA-HDBK-010 for design considerations.

For sites comprising multiple building structures, such as a building and antenna tower, configure the EES based on the following facility separations:

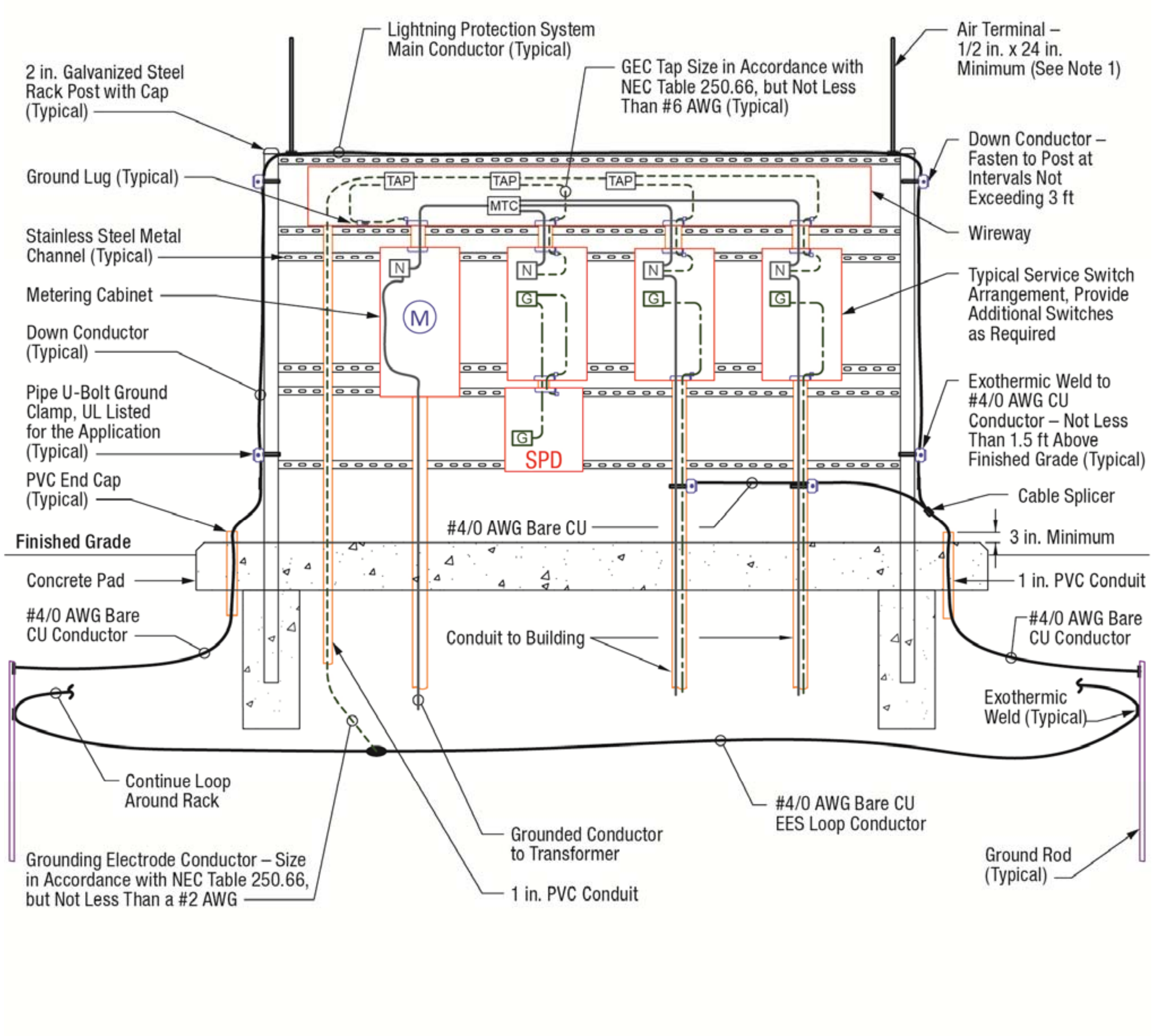
a. Less than 15 ft. A single EES loop designed to encircle the adjacent facilities is permitted.

b. Greater than 15 ft but Less than 30 ft. Design a separate EES for each facility, where adjacent EES loops may share a common side.

c. Greater than 30 ft but Less than 100 ft. Design a separate EES loop for each facility. Interconnect all EES loops by a minimum of two buried conductors, separated as widely as possible.

d. Greater than 100 ft. Design a separate EES for each facility. Interconnection of the separate EES is not required.

For small facilities, such as airfield navigation aids (NAVAIDS) or outdoor equipment service racks illustrated in Figure 4, an alternative EES design consisting of a minimum of two ground rods with a 4/0 AWG interconnecting ground wire is permitted.



Notes:

1. Only one air terminal, mounted at the center of the rack, is required for racks less than 6 ft in width.
2. Drawing is diagrammatic, phase conductors are not shown for illustrative purposes.

Figure 4. Typical Service Rack EES Installation – For Illustrative Purposes Only

4.4.4.1 Ground rods

Installation of ground rods shall meet the following requirements:

a. Material and Size. Ground rods shall be copper or copper clad steel, a minimum of 10 ft long and 3/4 in. diameter. Rod cladding shall not be less than 1/100 in. thick.

b. Spacing. Ground rods shall be as widely spaced as possible, and in no case spaced less than one rod length. Nominal spacing between ground rods is between two and three times the rod length.

c. Depth of Rods. Install top of ground rods at least 1 ft below grade level, or 1 ft below frost depth if required to suit climatic conditions.

d. Location. Rods shall be located 2 to 6 feet beyond the foundation or exterior footing of the structure, except at locations where abutting sidewalks, equipment, or other obstructions warrant locating rods farther away from the foundation. On buildings with overhangs or sidewalks in close proximity, then the ground rods are permitted to be placed at locations further out.

e. Orientation. Ground rods shall be driven at 90 degree (vertical) orientation to finish grade. If ground rods cannot be driven vertically to their full length, then the installation of grounding dissipation plates needs to be considered.

4.4.4.2 Interconnections

The EES installation shall include the following:

a. Counterpoise Loop. Ground rods shall be interconnected by a direct buried, bare 4/0 AWG copper conductor installed at least 2 ft below grade. Locate the counterpoise conductor and ground rods below the minimum frost depth. The interconnecting conductor shall close on itself forming a complete loop with the ends exothermically welded. Locate the counterpoise conductor and ground rods below the minimum frost depth with the exception of permafrost.

b. Exothermic Welds. Provide exothermic weld connections, except where prohibited by the NEC and at locations where welding creates hazards, such as near fuel tanks. In these cases, connections shall be installed with hydraulically crimped terminations using 12-ton minimum force applied with a tool using matching dies.

c. Building Structural Steel. Building perimeter steel columns shall be bonded to the EES at spacing intervals of approximately every other column, but not more than 60-ft intervals.

d. Reinforced Concrete Structures. Bond reinforcement bars to the EES once every 60 linear feet along the building foundation perimeter with a minimum 4/0 AWG bare stranded copper conductor exothermically welded or by a hydraulically crimped termination.

e. Underground Metallic Structures. Bond underground metallic pipes and tanks, except where prohibited by the NEC, such as gas piping.

f. Telephone Ground. Where present, the ground shall be connected to the EES by a bare copper conductor not smaller than 2 AWG.

4.4.4.3 Ground Dissipation Plates

In shallow soil locations with limited surface space, ground dissipation plates are permitted in lieu of ground rods in the EES. In difficult soils/areas, a combination of trenches filled with metallurgical coke and ground dissipation plates is highly recommended.

Installation of ground dissipation plates shall meet the following requirements:

a. Dissipation Plate Surface Area. Ground dissipation plates have four times the surface area of one ground rod, 3/4 in. diameter and 10 ft long. Therefore, substitute one ground dissipation plate for four ground rods.

b. Material and Size. Plates shall be fabricated and installed in accordance with Figure 6.

c. Spacing. Nominal spacing is 100 ft between ground plates.

d. Depth of Plates. Install plates to the same depth or deeper than the interconnecting EES counterpoise conductor, but maintain a minimum of 1 ft of native soil above the upper edge of the plate.

e. Location. The plates shall be installed at the corners of the EES at the farthest accessible point from the facility to be protected.

f. Orientation. Plates should be installed in a vertical plane to take advantage of seasonal moisture and temperature changes in the soil.

4.4.4.4 [A4] Access Well

Access wells are permitted to enable inspection and maintenance activities. When installed, the well should be located at a ground rod in unpaved areas with access to open soil, to allow for inspection. The access well shall be made from concrete or other approved material, with a removable cover. The access well shall provide a 12-in. minimum radius clearance from the center of the ground rod to the inside wall of the access well.

4.4.5 Grounding Enhancement Materials for Earth Electrode System (EES) Installation

Enhancement materials and methods are listed in order of preference.

4.4.5.1 Metallurgical Coke

Metallurgical coke is a steelmaking byproduct material of coal-to-coke production. Metallurgical coke is environmentally safe, stable, and conductive even when completely dry or frozen, moisture independent, compactable and economical to install.

Normal installation is in a 1-ft square trench filled with metallurgical coke in an EES configuration with a continuous 4/0 AWG stranded copper conductor in the center of the material per Figure 5. The top of the metallurgical coke trench shall be covered by a minimum of 1 ft of native soil. Metallurgical coke shall contain no more than 1 percent sulfur by weight. Charcoal and/or petroleum-based coke breeze shall not be substituted for metallurgical coke derived from coal in coke ovens. Charcoal and petroleum coke typically contain high levels of sulfur, which in the presence of moisture will accelerate corrosion of the EES. Placement of the trench is based on the geometry of the facility and the physical site location. Radial trenches with a center conductor can be used to enhance RF ground planes in communication facilities.

4.4.5.2 Engineered Soil Materials

Engineered soil materials are cements, soils, or clays treated with a variety of materials to enhance soil conductive properties. These materials may be used in bored holes for ground rod installations and in trenches for counterpoise conductors. These engineered soils can be a mixture of moisture-absorbing materials such as Bentonite or homogenous clays in combination with native soils and/or chemicals. Some engineered soil enhancements use cement-based materials, but should be avoided in areas subject to significant soil movement. Engineered soil should have a moisture content of greater than 14 percent to be effective.

4.4.5.3 Chemical Soil Enhancements

Chemical enhancements (doping) using materials such as mineral salts, Epsom salts, and sulfates, should only be used as a last resort to enhance soil conductive properties. These materials may be used in bored holes for ground rod installations and in trenches for counterpoise conductors. Chemical enhancement is dependent on soil moisture content and requires periodic (usually annual) re-treatment and continuous monitoring to be effective. The chemicals can leach into the surrounding soil and can be deposited into the water table.

4.4.5.4 Chemical Ground Rods.

Similar to chemical enhancements, chemical ground rods also require re-treatment and monitoring to ensure continuous effectiveness. Many of these systems require a drip irrigation system in dry soil conditions. Installation and periodic inspections shall be in accordance with manufacturer's instructions.

4.4.6 Installation of Earth Electrode Systems in Corrosive Soils

Careful consideration must be given to the installation of any grounding system in soils with corrosive elements. Two geological areas of known concern are the volcanic soils in Hawaii and Alaska. It is recommended that supplemental cathodic protection be applied to the grounding system at these locations. A buried steel plate acting as a sacrificial anode shall be connected to the EES by a 4/0 AWG stranded bare copper conductor. The 4/0 AWG conductor shall be exothermically welded to the EES and to the sacrificial plate. The conductor shall be welded to the center of the plate. The sacrificial plate shall be a minimum 2 ft by 2 ft by 1/2 in. thick, installed in a vertical orientation.

For enhanced performance in shallow soils, provide a ground dissipation plate design per paragraph 4.4.4.3 or equivalent. Provide sacrificial anodes in addition to these standard ground plates.

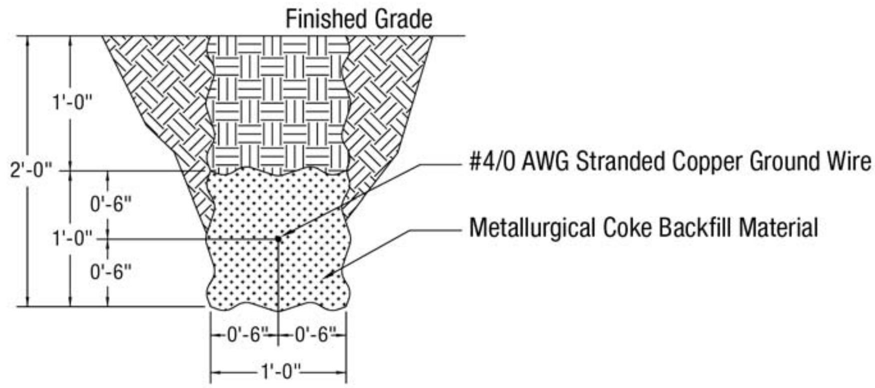


Figure 5. Grounding Trench Detail

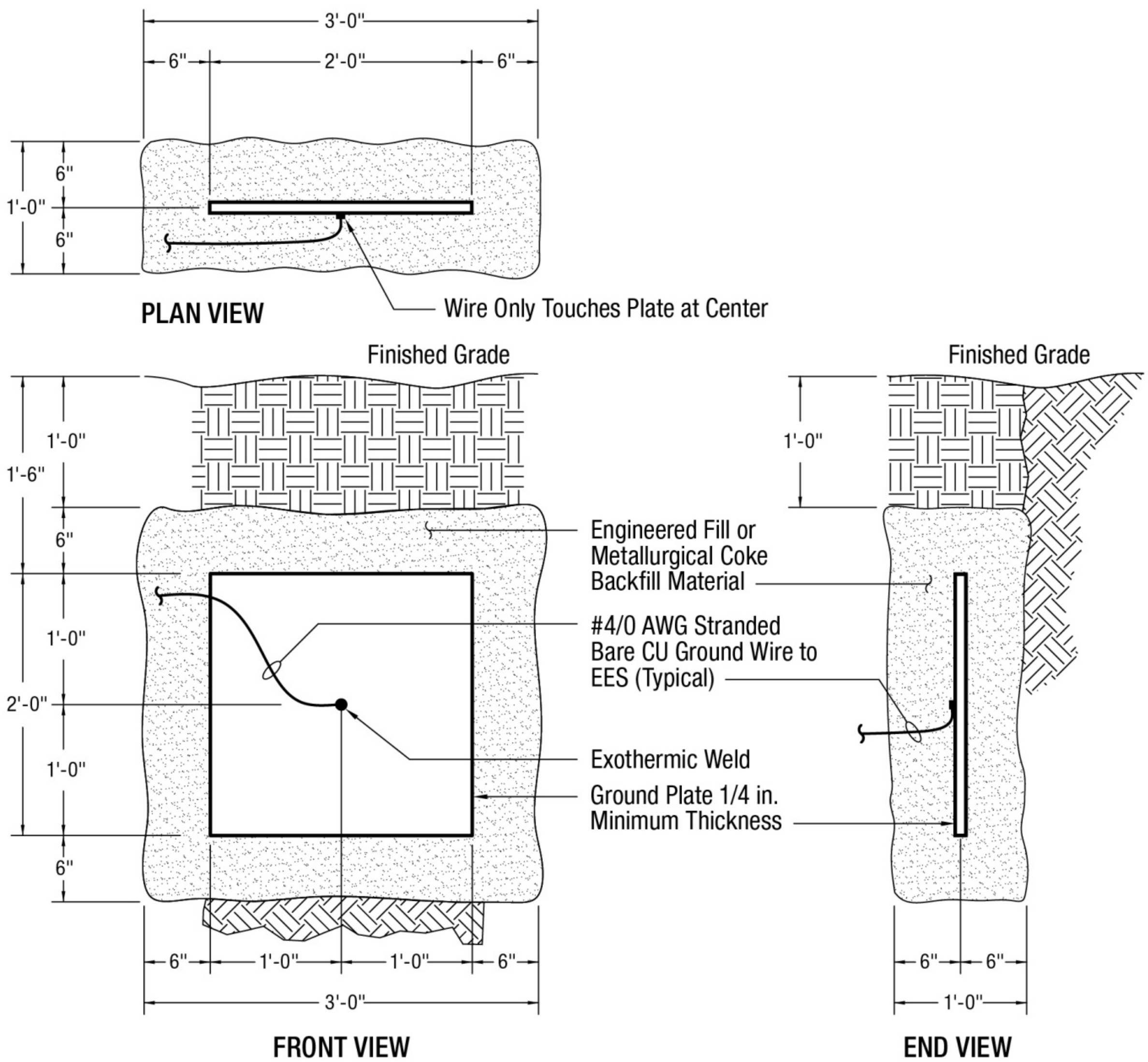


Figure 6. Ground Dissipation Plate Detail

4.5 National Electric Code - Power Distribution System Grounding Compliance

4.5.1 General

The facility electrical grounding shall exceed requirements of NEC Article 250 as specified herein.

4.5.2 Grounding Electrode Conductors (GEC)

Grounding electrode conductors (GEC) shall conform to the following:

a. GEC and Jumper Size. The GEC and system bonding jumper shall be sized in accordance with NEC Article 250.

b. GEC Termination and System Bonding Conductor. The GEC connection shall be terminated in the service disconnecting means (SDM). System bonding conductor shall be installed at the same location as the SDM.

c. GEC Splicing and Routing through Metal Enclosures. If the GEC is spliced using a hydraulically crimped connector, the connector shall comply with paragraph 4.2.3.2. When a GEC is routed through a metal enclosure, such as conduit, the enclosure shall be bonded with the same size conductor at each end to the GEC.

d. Separately Derived Systems. For a separately derived system, the system bonding jumper and the GEC shall be located at the first downstream system disconnecting means or overcurrent device. Connect the GEC directly to the EES, where possible, or terminate the GEC to the nearest effectively grounded structural steel member.

4.5.3 Equipment Grounding Conductors (EGC)

The EGC shall be a green insulated wire routed in the same raceway as the circuit phase and neutral conductors. Where power is supplied to electronic equipment through a cable and connector, the connector shall contain a pin to continue the EGC to the equipment chassis. Conduit or cable shields shall not be used as the sole EGC. Installation shall be in accordance with the NEC, FAA-C-1217, and the following:

a. Grounding Terminals in Receptacles on Multi-Outlet Assemblies. These terminals shall be hardwired to an EGC. Strips that depend on serrated or toothed fingers for grounding shall not be used.

b. Expansion joints. Conduit expansion joints shall be UL listed expansion joint fittings.

Where power conductors and the EGC are to be extended to a second building or structure, the neutral to ground bond of the power system shall originate at the first building electrical service entrance point. The grounded conductor shall not be connected to the EGC or EES at the second building or structure.

4.5.4 Grounding Bushings for Conduit Raceways

A grounding bushing is a conduit fitting that contains a lug for connecting a bonding jumper from the conduit bushing to the equipment ground bus or metal enclosure. This bonding jumper supplements the existing mechanical connection using locknuts and therefore improves the grounding integrity of the installation. The FAA has opted to exceed the minimum NEC raceway grounding bushing installation requirements for power and communication distribution systems that serve NAS facilities.

Provide grounding bushings for conduit raceway systems for the following conditions:

a. IMC and RMC Conduits. A grounding bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation (see Figure 7).

b. EMT Conduits. The connectors shall have an insulated throat, smooth bell shaped end, or a grounding bushing.

c. Communication Conduit Pathways. Provide grounding bushings where conduits enter or leave the building. Additional grounding bushings are not required for electrically continuous conduit pathways located inside the building, unless otherwise required for electronic equipment operations. Bond each conduit with a 6 AWG or larger size conductor to the nearest SRS (with the exception of the single point ground system). If there are multiple conduits in the same junction box, the conduits can be bonded to a new ground bus established within the junction box with a 6 AWG or larger size conductor connected to the SRS (with the exception of the single point ground system).

Exception. *Pullboxes and junction boxes are exempt from the grounding bushing requirement unless required by NEC or equipment installation requirement.*

4.5.4.1 Non-Current-Carrying Metal Equipment Enclosures

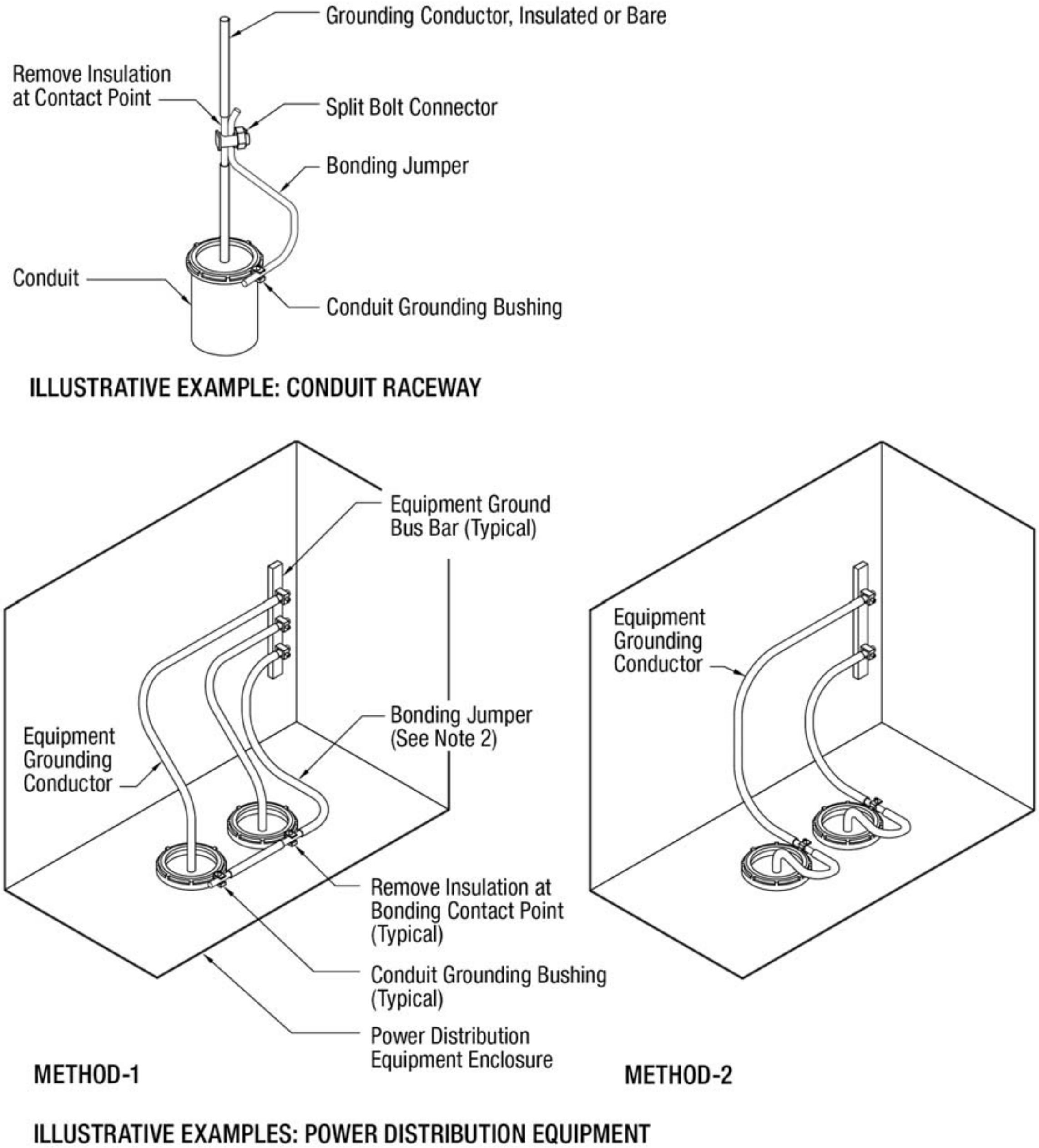
Non-current-carrying metal equipment enclosures include electrical equipment such as switchgear, panelboards, safety disconnect switches, raceways, and cable trays. The insulating finishes shall be removed between grounding and bonding areas of mating surfaces or bonding jumper connection points. The raceway systems shall be made electrically continuous in accordance with the following:

a. Noncontinuous Ferrous Conduit Pathways or Sleeves. Pathways used for routing conductors only shall be equipped with grounding bushings at each end of the conduit pathway. The grounding conductor shall be bonded to the bushings with a bonding jumper the same size as the grounding conductor, see Figure 7 illustrative example.

b. Continuous Conduit Systems. Systems that terminate at electrical equipment with grounding bushings as required in 4.5.4 shall be bonded to equipment ground bus with a bonding jumper the same size as the EGC. This shall be accomplished in accordance with Figure 7.

c. Ferrous Materials. These materials shall be used for enclosures, raceways, and cable trays when required to provide shielding from magnetic fields.

d. Battery Supporting Racks. These racks shall be bonded either directly to the EES or to a grounded structure with a minimum 2 AWG conductor.



Notes:

1. The illustrative examples depict typical bonding concept, other engineered solutions may be possible.
2. The bonding jumper shall be sized as large as the largest EGC going through the conduits being used for grounding bushings.

Figure 7. Bonding of Grounding Conductor to Conduit or Equipment

4.5.5 Interior Metal Piping Systems

Interior metal piping systems shall be bonded in accordance with the NEC.

Interior metal piping systems, such as mechanical and related metal piping systems located within the perimeter of SRS areas for NAS electronic equipment, shall be bonded in accordance with paragraph 4.7.3.2.

4.5.6 Building Structural Steel

Bonding of building structural steel elements shall be in accordance with the following:

a. NEC Compliance. At the electrical power service entrance and separately derived power source equipment, building structural steel shall be bonded in accordance with the NEC.

b. Periphery of NAS Equipment Room. Main building structural steel members of columns and beams at the periphery of NAS electronic equipment rooms shall be electrically continuous. This shall be accomplished by either direct or indirect bonding of the columns and beams. Where direct bonding is not practical, indirect bonds with copper conductor shall be used with a minimum of two 2 AWG conductors per 100 ft^2 of steel decking, metallic wall covering, etc. These connections shall be applied via an exothermic weld or a hydraulically crimped two-hole termination. Surface coatings shall be removed in accordance with paragraph 4.2.4.1**.**

c. Building Perimeter Steel. Building perimeter steel columns shall be bonded to the EES in accordance with paragraph 4.4.4.2c.

Exception. *Concrete-encased steel reinforcement used in precast construction elements is exempt from the bonding requirements.*

4.6 Surge Protection Device (SPD) Requirements

4.6.1 General

SPDs shall be provided at locations where electrical power systems are susceptible to conducted power line surges. SPD equipment functional performance requirements are detailed in section 5.7. Selection of appropriate SPD depends on location and application. The SPDs and transient suppression provided at electronic equipment power line entrances shall be coordinated as required herein and paragraph 5.6.4.

4.6.2 SPD for Power Distribution System

SPDs shall be provided at the following locations:

a. Service Disconnecting Means. Provide SPD on the load side of the SDM.

b. Facility Entrance Point. Provide SPD on the load side of a facility entrance point. For example, if the facility entrance point is within a NAS electronic equipment room, the SPD is required at the first distribution panelboard that supplies the branch panelboards within the room.

c. Transfer Switch, Switchboard, or Panelboard. Provide SPD either on the load side of an engine generator transfer switch, or on the first switchboard or distribution panelboard located downstream of the transfer switch.

d. Panelboards Feeding Building Exterior Loads. Provide SPDs at panelboards that supply branch circuit wiring exiting the building to serve exterior equipment.

e. Secondary Transformer. Provide SPD at separately derived power source that feeds NAS electronic equipment.

A lightning arrester shall be installed on the primary side of FAA-owned distribution transformers. Lightning arresters and SPDs shall be approved by the OPR.

4.6.2.1 SPD for Facility Entrance Equipment

SPDs shall be provided at the SDM, at all facility entrance penetrations, and at feeder and branch panelboards as specified in paragraph 4.6.2.2. Additional SPDs shall be provided at the power line entrances to operational electronic equipment.

4.6.2.2 SPD for Power Distribution Feeders and Panelboards

SPDs shall be installed on switchgear, panelboards, and disconnect switches providing service to NAS operational equipment or supplying exterior circuits.

Examples of exterior circuits include obstruction lights, convenience outlets, guard houses, security systems, electric gates, and feeds to other facilities.

Where feeder and branch panelboards are located close together and their panelboards do not serve exterior circuits, use the SPD location decision tree diagram, Figure 8, to determine if an SPD is required for branch panelboards. SPDs for panelboards that provide service to exterior circuits shall meet requirements of paragraphs 5.7.2.1.1, 5.7.2.1.2, and 5.7.2.1.3 for facility entrance SPDs.

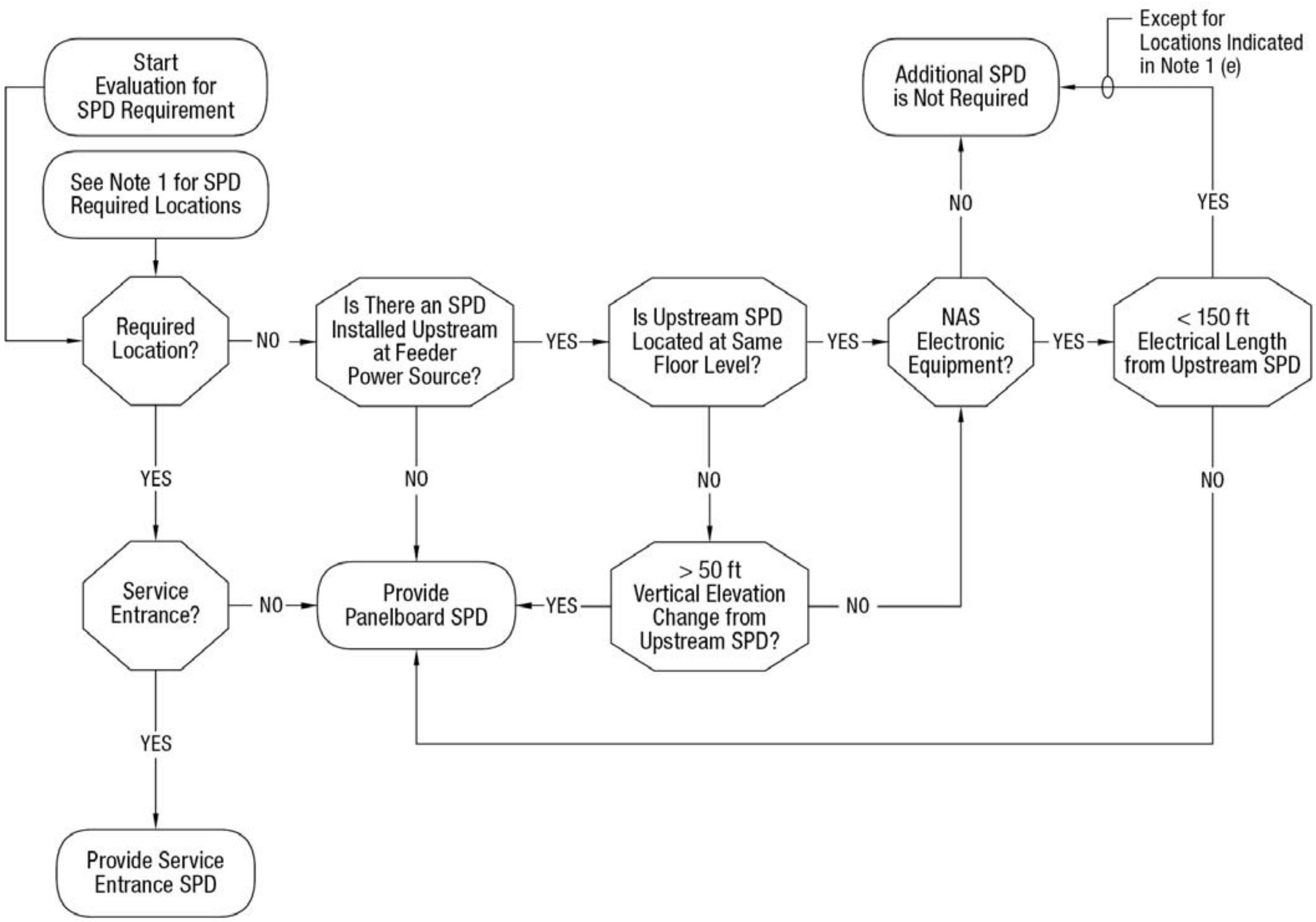
SPDs shall be installed as close as possible to the panelboard they serve and in accordance with the manufacturer's instructions. A feeder or branch panelboard SPD shall be provided with an overcurrent protection device. Overcurrent protective device (OCPD) examples include a fuse or circuit breaker fitted internal to the SPD or fitted to the panelboard and dedicated to the SPD. The overcurrent device shall not increase the clamp voltage of the SPD by more than 5 percent and shall pass the surge current values listed in Table 11 up to the 40 kA level without opening. Overcurrent devices for exterior circuits shall pass all surge current values in Table 11. Overcurrent devices, both internal and external to the SPD, and SPD short circuit current ratings, shall be sized and coordinated in accordance with the NEC and be field resettable or replaceable.

4.6.2.3 SPD Installation Requirements

SPDs shall be installed as close as possible to the panelboard or equipment that is being protected. Conductors shall be made as short as possible. Connections shall be made with UL listed connectors identified for the wire size and type used.

a. Connections. Install the maximum conductor size allowed by the SPD manufacturer, but do not exceed the incoming circuit phase and grounding conductor size permitted by the panelboard, SDM , or protected equipment. Conductors shall be color-coded in accordance with FAA-C-1217, and as short and direct as possible without loops, sharp bends, or kinks. The ground bus in the service entrance enclosure shall be bonded directly to the SPD terminal marked G or ground. The SPD enclosure shall be bonded to the SPD ground terminal.

b. Conduit Sealing. The conduit connecting the SPD enclosure to the SDM enclosure or panelboard shall be sealed with duct seal or other UL listed nonflammable, inorganic potting material to prevent soot from entering the protected enclosure in the event of SPD failure.



<u>Notes:</u>

1. Provide SPDs in accordance with paragraph 4.6.2 and for the following locations.
   a. Power service disconnecting means (SDM).
   b. Load side of automatic transfer switch (ATS).
   c. Transformer, secondary of separately derived power source.
   d. Panelboards with branch circuits that feed building exterior loads.
   e. Power feeder that supplies the panelboards for NAS electronic equipment room. SPD is required at the first panelboard located within the room.

Figure 8. SPD Location Diagram - Close Proximity Allowance Decision Tree

4.6.3 SPD for Signal, Control, and Data Line Surge Protection

Provide SPDs at the following locations:

a. Facility entrances,

b. Entrances to NAS electronic equipment (see paragraph 5.6.3),

c. Entrances to electronic equipment installed by the telecommunication service provider.

4.7 Grounding and Bonding for NAS Electronic Equipment Areas

4.7.1 General

This section describes grounding and bonding requirements for protection of NAS electronic equipment housed in designated NAS electronic equipment areas within FAA Facilities. Aspects of the grounding and bonding system include the following:

a. NAS Facilities Main Grounding Connection. This connection requires a main and supplemental ground plate, designed in accordance with paragraph 4.7.2. See paragraph 5.2.3 for ATCT facilities special requirements.

b. Signal Reference Structures. The SRS system requires grounding elements designed in accordance with paragraph 4.7.3.

4.7.2 Main and Supplemental Ground Plates

A main ground plate shall be established as a common point of connection for SRSs for the entire facility.

A supplemental ground plate shall be established at the opposite side of the facility to the main ground plate. This supplemental ground plate shall be used for a second connection of the multipoint ground system, signal reference grid, or signal reference plane to the EES. The use of multiple supplemental ground plates is permitted at large facilities.

Both the main ground plate and the supplemental ground plates shall conform to the following:

a. Located within 50 ft of the EES.

b. Each plate shall be connected to the EES with a 500 kcmil conductor.

c. Supplemental ground plates and the main ground plate shall be interconnected with an insulated 4/0 AWG cable, color coded with green and orange tracer.

See Table 4 for the main and supplemental ground plate installation requirements. See Figure 9 for typical facility grounding system.

***Exception*.** *For buildings of 200 ft^2 or less, only the main ground plate is required. Connect the main ground plate to the EES with two 4/0 AWG stranded copper conductors. One of the conductors shall be 20 percent longer than the other. All signal grounding, single point or multipoint, shall terminate on this plate. No additional ground plates are required.*

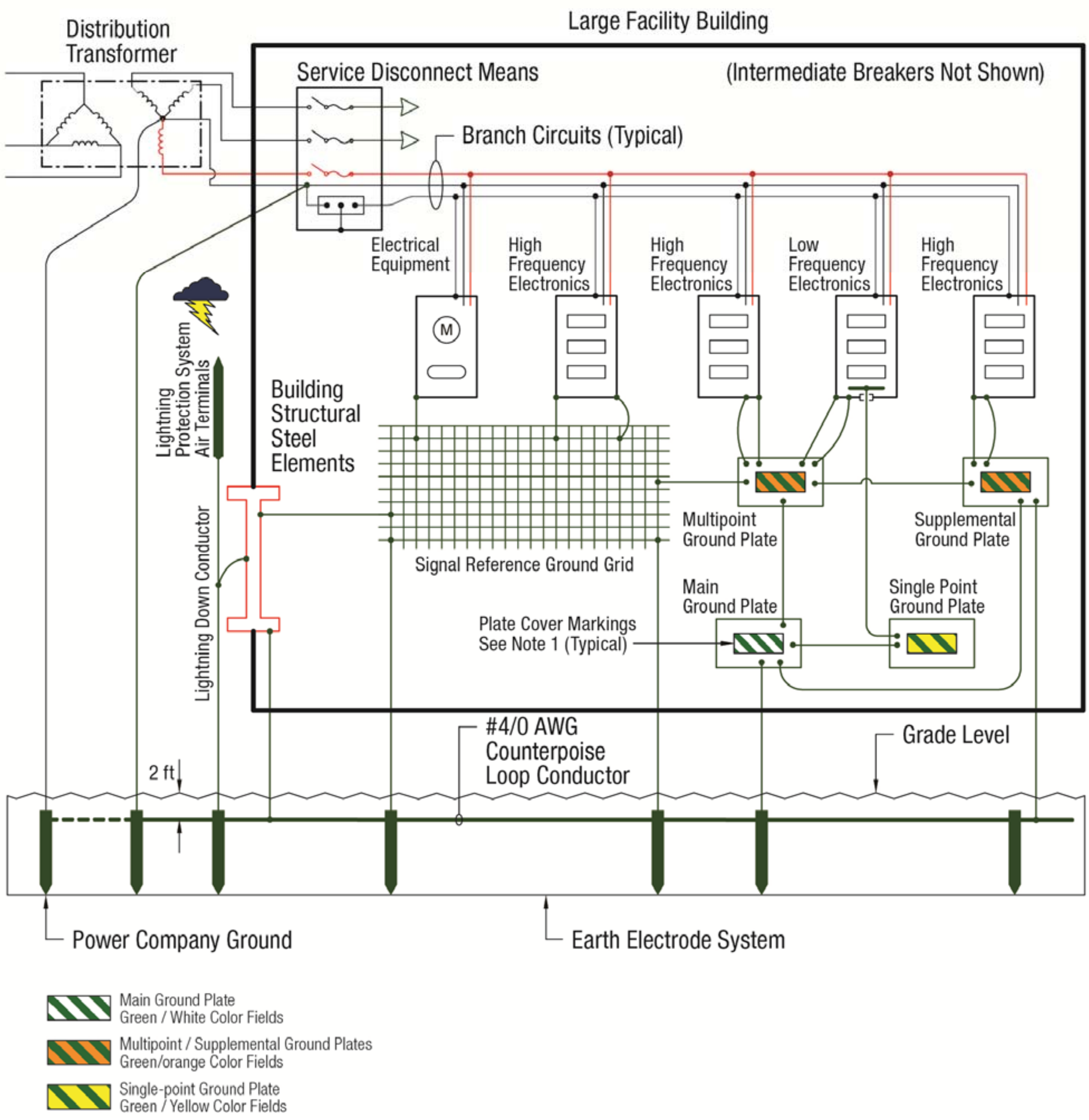


Figure 9. Typical Facility Grounding System

4.7.3 Signal Reference Structures (SRS) – Requirements

Enclosed building facilities used to house NAS electronic equipment shall be equipped with an SRS. Types of SRS include the following systems:

a. Multipoint Ground System (MPG) constructed using conductors and ground plates.

b. Signal Reference Ground Grid (SRGG) constructed using copper strips.

c. Signal Reference Ground Plane (SRGP) constructed using copper sheets.

d. Single Point Ground System (SPG) is a special grounding system defined in section 5.5. This topology shall only be installed as directed in section 5.5 and connected to the MPG, SRGG, or SRGP as directed in section 5.5, and it shall not be used as an applicable SRS as outlined in the rest of 4.7 and its sub-sections.

e. Engineered Hybrid System is a combination of MPG, SRGG, or SRGP grounding systems.

Provide an SRS for the following areas:

a. NAS Operations Areas. Entire room area.

b. Other Electronic Equipment Areas. Areas containing electronic equipment supporting NAS operations. Provide for the entire room area.

c. Other Power Conditioning Equipment Areas. Areas containing power conditioning equipment, such as site wide uninterruptible power supply (UPS), shall be bonded to the SRS system described above.

The above-referenced electronic and electrical equipment shall be bonded to the SRS in the area. SRSs located on the same floor or on different floors shall be bonded together using at least two separate paths. Multiple components of the facility SRS, but not the SPG system, shall be bonded together with a minimum of two 4/0 AWG conductors.

Design SRS systems for site-specific requirements of the facilities and equipment. SRS applications require analysis of equipment bandwidth, and equipment and SRS impedances. SRS analysis shall consider, among other parameters, operating frequencies and impedances, transmission line communication models for bonding wires, noise levels in low-frequency analog-based equipment, and the influence of high-frequency digital signal and logic equipment. All conductors and cabling of NAS electronic equipment systems operating nominally at a wavelength less than $\lambda/20$ of the highest system frequency shall lay on or very close to the SRS. Bonding connections between the electronic equipment and SRS shall be close-coupled so that the bonding jumpers are as short as possible, and routed to the nearest SRS connection point.

The SRS shall be located in the vicinity of the electronic equipment. Signal-carrying conductors, axial lines, waveguides, and cabling interconnections between equipment shall be routed in immediate proximity to the SRS. For overhead feeds, use overhead SRS systems. For underfloor feeds in raised access floors, use underfloor SRS systems. Where equipment is fed from both overhead and underfloor feeds, use a hybrid SRS system made up of MPG, SRGG or SRGP bonded together. MPGs, SRGGs, and SRGPs may be installed on ceilings, walls, or floors.

If NAS electronic equipment is installed in non-NAS electronic equipment rooms such as administrative areas, the NAS electronic equipment shall be bonded to a nearby SRS system. If there is no nearby SRS system, then establish a new MPG based on the footprint area of the NAS electronic equipment. If the square footage of the area is small enough, then install a small MPG system in accordance with paragraph 4.7.2.

The MPG and SRS systems shall be connected to the main and supplemental ground plates with conductors sized in accordance with paragraph 4.7.3.1.3. Each connection shall be to the nearest MPG plate or SRS.

4.7.3.1 Multipoint Ground System (MPG)

The protection of electronic equipment against potential differences and static charge buildup shall be provided by interconnecting non-current-carrying metal objects to an MPG that is effectively connected to the EES. The MPG consists of a network of plates and bonding jumpers, racks, frames, cabinets, conduits, wireways, cable trays enclosing electronic conductors, structural steel members, and conductors used for interconnections. The MPG shall provide multiple low-impedance paths to the EES, between various parts of the facility, and between electronic equipment within the facility so that any point of the system has a low-impedance path to the EES. This will minimize the effects of spurious currents present in the ground system due to equipment operation or malfunction, or from lightning discharges. The MPG shall not be used in lieu of the safety ground required by the NEC or as a signal return path.

4.7.3.1.1 Labeling

The MPG shall be clearly labeled to preserve its identity as described in the following paragraphs.

4.7.3.1.1.1 Conductor Identification

MPG conductors shall be labeled in accordance with paragraph 4.7.3.1.6.

4.7.3.1.1.2 Ground Plate Labeling

Ground plates shall be installed in accordance with Table 4.

4.7.3.1.2 MPG - Ground Plates and Buses

Multipoint ground plates shall be located to facilitate the interconnection of equipment cabinets, racks, and cases within a particular area. If more than one ground plate is necessary, they shall be located throughout the facility. Ground buses may be used when distributed grounding is required along a long continuous row of electronic equipment cabinets.

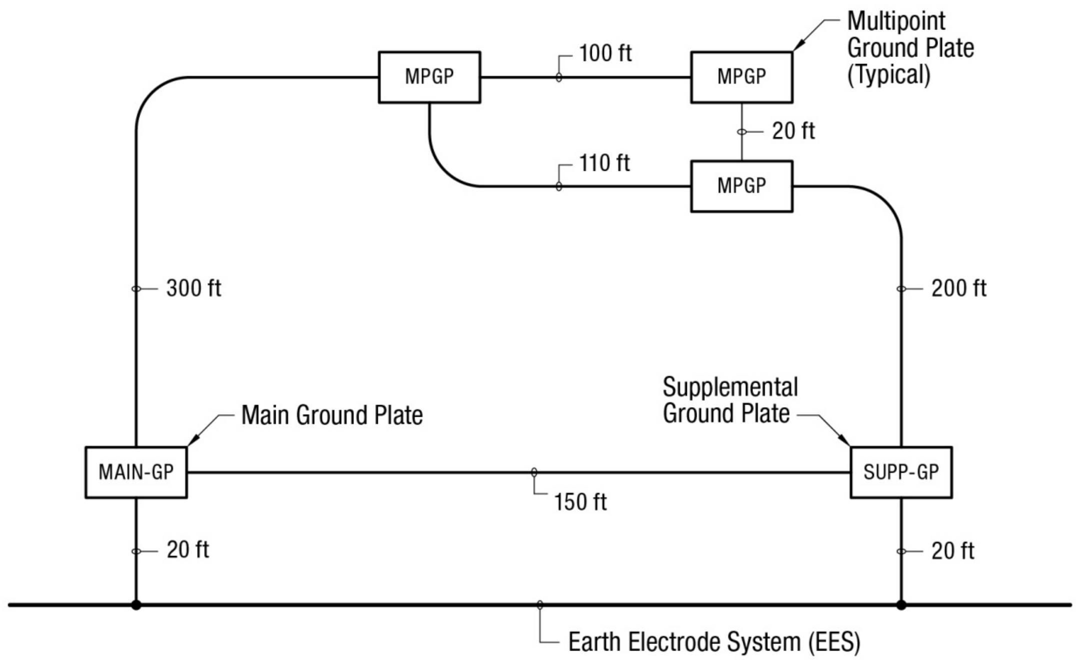
See Table 4 for the multipoint ground plate installation requirements. Ground buses shall be copper material. Ground bus width and thickness shall be selected from Table 3, and shall be as long as required.

Provide a secondary conductor return path for each MPG plate or ground bus. A single-ended, radial connected plate or bus configuration is not permitted. Building structural steel shall not be used as a secondary return path for the MPG.

4.7.3.1.3 MPG Conductors – Plate to Plate and Plate to Bus

Conductors between plates and buses in the multipoint system shall be insulated and sized in accordance with Table 3 based on the maximum path length to the farthest point in the MPG from the EES. To determine the distance to the farthest point in the multipoint system, add the length of conductors in the multipoint system to reach the farthest plate in the system via the longest path as shown in Figure 10. Divide the sum obtained by two to obtain the maximum path length. Use this path length to determine the conductor size from Figure 10, but in no case use a conductor smaller than 4/0 AWG. These conductors shall be insulated, labeled, and color-coded in accordance with paragraph 4.7.3.1.6. In cable trays, ground conductors shall be insulated and separated as far as possible from the other conductors.

<u>Exception</u>. *In plenum spaces, where plenum-rated insulated conductors are not available, bare ground conductors are permitted.*



<u>Notes:</u>

1. Determine the longest cable path between the main and supplemental ground plate connections to the EES by adding the sum of individual cable segments along the pathway.

   Maximum path length = 20+300+100+20+200+20 = 660 ft

2. Divide total obtained in step 1 by two.

   660/2 = 330 ft

3. Determine conductor size from Table 3. Using 330 ft path length, select 750 kcmil size conductor.

Figure 10. Multipoint Ground Conductor Size Determination

Table 3. Size of Electronic Multipoint Ground Interconnecting Conductors

Conductor Size (AWG or kcmil)	Max. Path Length (ft)	Bus Bar Size, See Note 2 (in.)	Max. Path Length (ft)
750, See Note1	375	4 x 1/4	636
600, See Note1	300	4 x 1/8	318
500	250	3 x 1/4	476
350	175	3 x 1/8	238
300	150	2 x 1/4	318
250	125	2 x 1/8	159
4/0	105	2 x 1/16	79
3/0	84	1 x 1/4	159
2/0	66	1 x 1/8	79
1/0	53	1 x 1/16	39
1	41		
2	33		
4	21		
6	14		
8, See Note 3	9		
10, See Note 3	6		
12, See Note 3	4		

Notes:

1. Where these conductors are not available, parallel conductors are permitted, such as three 250 kcmil conductors in place of one 750 kcmil conductor, or two 300 kcmil conductors in place of one 600 kcmil conductor. Conductor sizing is based on providing a cross-sectional area of 2,000 cmil per linear ft. Bus bar sizes are chosen from available cross-sections and shall exceed the cross-sectional requirement of 2,000 cmil per linear ft.
2. Denotes an MPG designed with a continuous bus bar layout in lieu of ground plates and interconnecting conductors.
3. Conductor wire sizes 12 AWG through 8 AWG are permitted only for bond jumper connections between subassemblies and interior cabinet ground plate within the electronic equipment enclosure.

Table 4. Ground Plate Specification Requirements

Plate Type	Acronym	Application Requirements (see article)	Material	Configuration Notes	Identification Notes
Main	Main-GP	4.7.2	Copper	1, 2, 3, 4	5, 6
Supplemental	Supp-GP	4.7.2	Copper	1, 2, 3, 4	5, 6
Multipoint	MPGP	4.7.3.1	Copper	1, 2	5, 6
Single Point	SPGP	5.5.4	Copper	1, 2	5, 6

Notes:

1. Plate Dimensions. Ground plate dimensions shall be at least 4 in. wide and 1/4 in. thick. Provide adequate length to accommodate number of bond connections plus at least two spare positions.
2. Conductor Terminations at Ground Plates. Provide either UL listed hydraulically crimped 2-bolt-hole style terminal lugs or exothermic welds for conductor terminations.
3. Conductor Terminations at the EES. The connections from ground plates to the EES shall be made with exothermic welds at the EES. The connections shall be as follows:
   a. Conductor between Main-GP and EES. Provide at least one 500 kcmil conductor. The Main-GP location shall be chosen to minimize conductor length, but shall not be more than 50 ft from the EES.
   b. Conductor between Supp-GP and EES. Provide at least one 500 kcmil conductor. The Supp-GP location shall be chosen to minimize conductor length, but shall not be more than 50 ft from the EES. The conductor length from Supp-GP to the EES shall be 30 percent longer or shorter than the conductor between the Main-GP and the EES.
4. Interconnection of Main-GP and Supp-GP. Provide a 4/0 AWG bonding conductor connected between the Main-GP and Supp-GP.
5. Ground Plate Covers. Provide clear plastic covers with a permanently attached label or metal nameplate. The nameplate text shall be color black with 3/8-in. high letters and Arial font. The cover shall be identified with color-coded overlay markings configured by system type. The nameplate caption and cover identification shall be as follows:
   a. Main-GP. Provide label caption, “MAIN GROUND PLATE” and cover markings with clear background and green slashed marking tags around the caption.
   b. Supp-GP. Provide label caption, “SUPPLEMENTAL GROUND PLATE” and cover markings with clear background and green slashed marking tags around the caption.
   c. MPGP. Provide label caption, “MULTIPOINT GROUND PLATE” and cover markings with green background and bright orange slashed marking tags around the caption.
   d. SPGP. Provide label caption, “SINGLE POINT GROUND PLATE” and cover markings with green background and bright yellow slashed marking tags around the caption.
6. Conductor Identification Requirements. See Table 5.

4.7.3.1.4 MPG Conductors - Plate and Bus to Equipment

Conductors from plates and buses in the multipoint system to equipment chassis shall be sized in accordance with Table 3 based on the maximum path length from the plate or bus to the equipment. These conductors shall be insulated, labeled, and color-coded in accordance with paragraph 4.7.3.1.6. In cable trays, ground conductors shall be separated as far as possible from the other conductors. In wireways, ground conductors shall be visible by opening any cover.

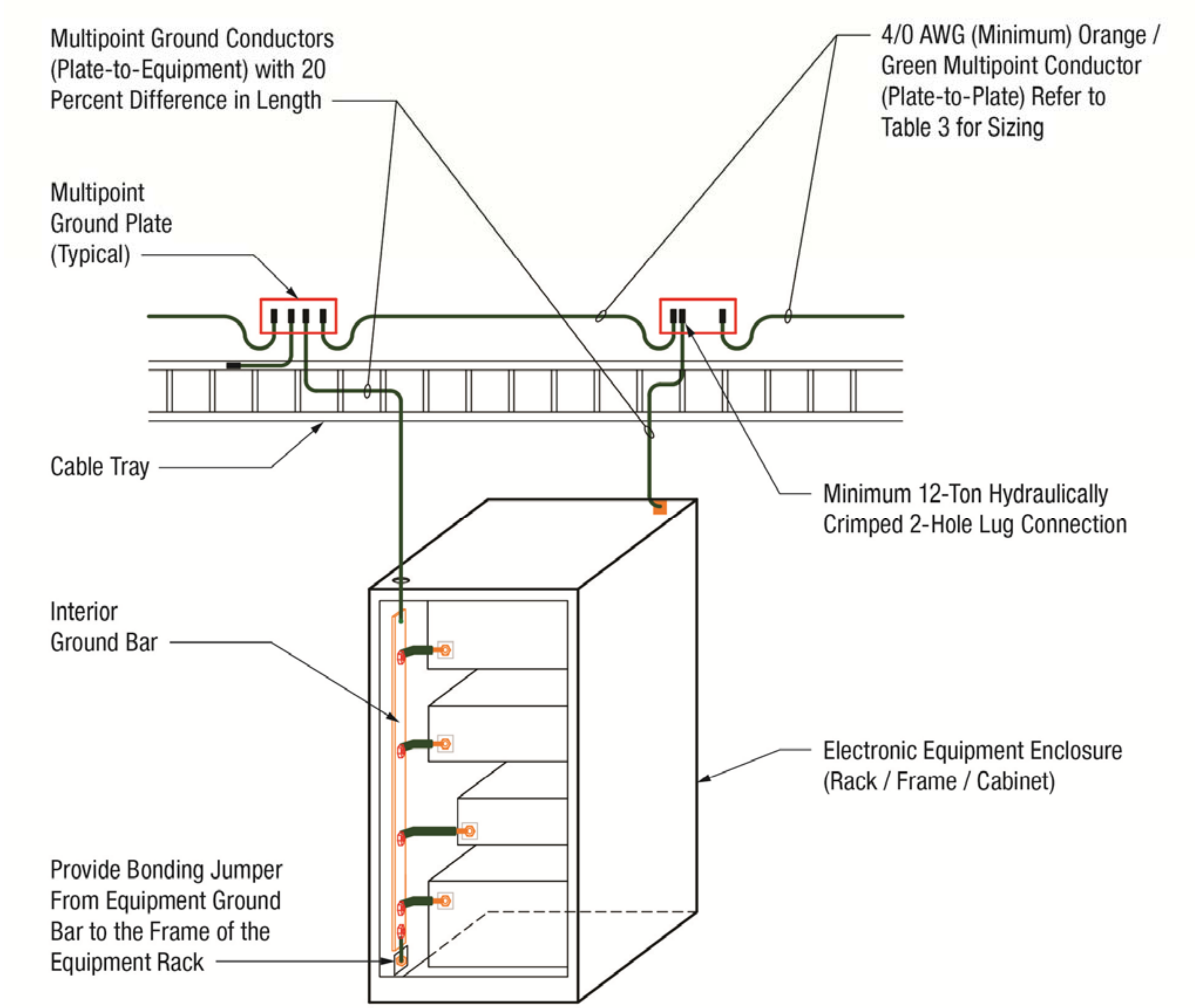
Provide grounding connections between the electronic enclosure and the MPG system in accordance with following:

a. Bonding Connections. Bonding connections shall prevent resonant impedances at equipment operating frequencies. Provide two short low-impedance bonding jumper between the MPG and two corners of the equipment. These bonding jumpers shall be connected as far apart as possible on the equipment (ideally on opposite corners) to reduce mutual inductance, and they shall have few bends or sags. The two bonding connections shall be of unequal length (one of the connections shall be 20 percent longer or shorter than the other) so that if one strap undergoes resonance, by limiting current flow, the other strap will not. Any bend radius in the bonding conductors shall be a minimum of 8 in.

b. Bonding Connectors. Provide bonding conductors size in accordance with Table 3 at MPG system connections.

c. Bonding Connection Length. Bonding connections to the SRS should be as short as possible.

See Figure 11 for typical electronic equipment grounding illustrations.



ILLUSTRATIVE EXAMPLE:

Notes:

1. If MPG conductors are mounted on the side or face of the cable tray, provide cable support at intervals of at least 3 ft. MPG conductor support is not required if the cables are laying on the cable tray system.
2. Paint shall be removed from the bonding surfaces before making grounding connections to the equipment enclosure. The bonding surfaces do not require paint sealing treatment if the connection is made inside an environmentally controlled room.

Figure 11. Electronic Equipment Grounding

4.7.3.1.5 Grounding Conductor Protection
Provide protection for MPG conductors subject to physical damage by use of conduit, floor trenches, routing behind permanent structural members, or other approved means. If grounding conductor is routed through metal conduit, the conduit shall be bonded to the conductor at each end.

4.7.3.1.6 Grounding Conductor Labeling
Provide conductor and pathway identification labeling where cables pass between areas physically separated by walls. Labeling is not required for cables that originate and terminate in the same room, such as a room without wall partitions.

Table 5. Grounding Conductor Insulation Color Codes

Conductor Insulation - Color Identification	Use
Green with red and yellow tracers	Isolated grounds
Green with yellow tracer	Single point ground
Green with orange tracer	Multipoint ground
Green with red tracer	High-Transient ground

Notes:
1. Some commercial off-the-shelf (COTS) equipment uses green with yellow tracer as the color identification for the EGC. These conductors are permitted.
2. Conductor labeling material type and format specification shall be in accordance with FAA-C-1217.

4.7.3.2 Signal Reference Ground Grid (SRGG)
When required, the SRGG shall be provided for raised access floor systems and/or ceiling systems in NAS electronic equipment rooms or areas serving NAS electronic equipment.

The SRGG shall be configured in accordance with the following:

a. Configuration. SRGG shall consist of a grid of 2-in. wide copper strips, 26 gauge or thicker, placed on a 2x2-ft square grid and welded at each grid intersection.

b. Installation Location. SRGG shall be installed below a raised access floor system, below a ceiling or above a suspended ceiling system, or both. The SRGG perimeter shall extend to within 6-in. from the room perimeter or the perimeter of electronic equipment area served.

c. Perimeter Conductor. A minimum 4/0 AWG bare copper conductor loop shall be routed around the SRGG and located within 6 in. from the SRGG perimeter. The SRGG perimeter shall be bonded to the perimeter loop conductor at every grid intersection with a 4 AWG bare copper conductor.

d. Bonding to EES. The perimeter loop conductor shall be bonded to the EES with a minimum of four 4/0 AWG conductors spaced as widely apart as possible.

e. Bonding to Building Steel. Building structural steel located within 6 ft of the SRGG perimeter loop conductor shall be bonded to the loop conductor with minimum 4/0 AWG conductor. Building structural steel located within the perimeter of the SRGG shall be bonded to the SRGG with a minimum 4 AWG conductor.

f. Bonding to Floor and Ceiling Systems. The SRGG shall be bonded to the raised access floor system or the ceiling metalwork at intervals not less than 6 ft using minimum 4 AWG bare copper conductors.

g. Bonding of Multiple SRGGs. Floor and ceiling portions of a SRGG in the served area shall be bonded together with a minimum of four sets of 4/0 AWG conductors spaced as wide apart as possible.

h. Bonding of Raceways and Metal Objects. Conduits, wireways, pipes, cable trays, or other metallic elements that penetrate the SRGG area shall be bonded to the SRGG where they enter the area and every 25 ft for their entire length within the area. Conduits, wireways, pipes, cable trays, and other metallic elements within 6 ft of the grid shall be bonded to the SRGG. These bonds shall be minimum 4 AWG bare copper conductors.

4.7.3.2.1 SRGG to Equipment

Provide bonding straps 1 in. wide and at least 26 gauge solid copper at SRPG or SRGG connections.

4.7.3.3 Signal Reference Ground Plane (SRGP) - Special Conditions

SRGP is a continuous signal reference ground plane constructed of 24 gauge minimum thickness copper sheets. SRGP shall be provided when required by the electronic equipment vendor. SRGP designs shall be approved by the OPR.

4.7.4 Bonding of Electrical Systems in NAS Electronic Equipment Areas

Raceways/conduits, wireways, and electrical distribution equipment shall be bonded to the SRS. Metal framing channel systems used to support conduit/raceway or other equipment are expected to be installed to achieve electrical continuity, and are not required to have additional bonding jumpers between individual assembly components.

4.7.4.1 Conduit Raceways

Every component of metallic conduit runs such as individual sections, couplings, line fittings, pull boxes, junction boxes, and outlet boxes shall be made electrically continuous and bonded, either directly or indirectly, to the SRS or facility steel at intervals not exceeding 25 ft.

If otherwise not indirectly or directly bonded, bond conduits using a minimum 6 AWG bonding conductor. Conduit raceways that are less than 1.5 in. trade size or less than 10 ft in length are exempt from the bonding requirement.

4.7.4.2 Cable Trays and Wireways

If not indirectly or directly bonded, bond individual sections of metallic cable tray and wireway systems together with a minimum 6 AWG insulated copper conductor. Bonds shall be in accordance with section 4.2.

Bonding jumpers between individual sections are not required when all of the following conditions are met:

a. The cable tray or wireway systems are electrically continuous,

b. The systems are UL classified, suitable for use as an EGC,

c. The systems are installed in accordance with manufacturer recommendations.

Where installed in electronic areas, cable trays and wireways shall be bonded to the SRS within 2 ft of each end of the run and at intervals not exceeding 50 ft. The minimum size bonding conductor for connection of a cable tray and wireway to the SRS shall be 2 AWG copper conductor.

4.8 Shielding Requirements

4.8.1 General

The facility design and construction shall include both protective shields to attenuate radiated signals, and separation of equipment and conductors to minimize interference coupling. The equipment design shall incorporate component compartments and overall shields as necessary to meet the electromagnetic susceptibility and emission requirements of MIL-STD-461 as required by NAS-SS-1000 and FAA-G-2100. In addition, the design shall provide personnel safety protection shielding.

4.8.2 Facility Shielding

Shielding of facility buildings, shelters, and equipment spaces shall be provided when other facility or environmental sources of radiation are of sufficient magnitude to degrade the operation and performance of electronic equipment or systems.

4.8.3 Shielding for Conductors and Cabling

Conductor and cable shielding shall comply with the following:

4.8.3.1 Cables and Signal Lines

Cables consisting of multiple twisted pairs shall have individual shields for each twisted pair. The shields shall be isolated from each other. Cables with an overall shield shall have the shield insulated and isolated from individual shields.

Exception. *Structured cabling for computer and telephone networks, such as Ethernet over balanced-line twisted pair with differential signaling design for noise rejection, are permitted to be used without individual shields for each twisted pair.*

4.8.3.2 Cables - Termination of Individual Shields

Shields of pairs of conductors, line shields, and the shield of cables containing unshielded conductors shall be terminated in accordance with the following:

a. Shield Terminations. Shields shall be terminated to ensure correct equipment operation.

b. Shield Termination Lengths. Shield terminations shall consist of minimum length pigtails between the shield and the connection to the bonding halo or ferrule ring and between the halo or ferrule ring and the shield pin on the connector. The unshielded length of a signal line shall not exceed 1 in. with not more than 1/2 in. of exposed length as the desired goal.

c. Shield Isolations. Shields, individually and collectively, shall be isolated from overall shields of cable bundles and from electronic equipment cases, racks, cabinets, junction boxes, conduit, cable trays, and elements of the MPG. Except for one interconnection, individual shields shall be isolated from each other. This isolation shall be maintained in junction boxes, patch panels, and distribution boxes throughout the cable run. When a signal line is interrupted such as in a junction box, the shield shall be carried through. The length of unshielded conductors shall not exceed 1 in. To meet this requirement, the length of shield pigtail longer than 1 in. shall be allowed but shall be the minimum required.

d. Circuits and Chassis. Circuits and chassis shall be designed to minimize the distance from the connector or terminal strip to the point of attachment of the shield grounding conductor to the electronic signal reference. The size of the wire used to extend the shield to the circuit reference shall be as large as possible but not less than 16 AWG or the maximum wire size that will fit the connector pin. A common shield ground wire shall not be used for input and output signals, high and low level signals, signal lines, electronic signal lines, control lines, and power conductors.

e. Extensions. Extension of shields through the connector or past the terminal strip to individual circuits or chassis is permitted if required to minimize unwanted coupling inside the electronic equipment. Where extensions of this type are necessary, overall cable or bundle shields shall be grounded in accordance with paragraph 4.8.3.3.

4.8.3.3 Cables - Termination of Overall Shields

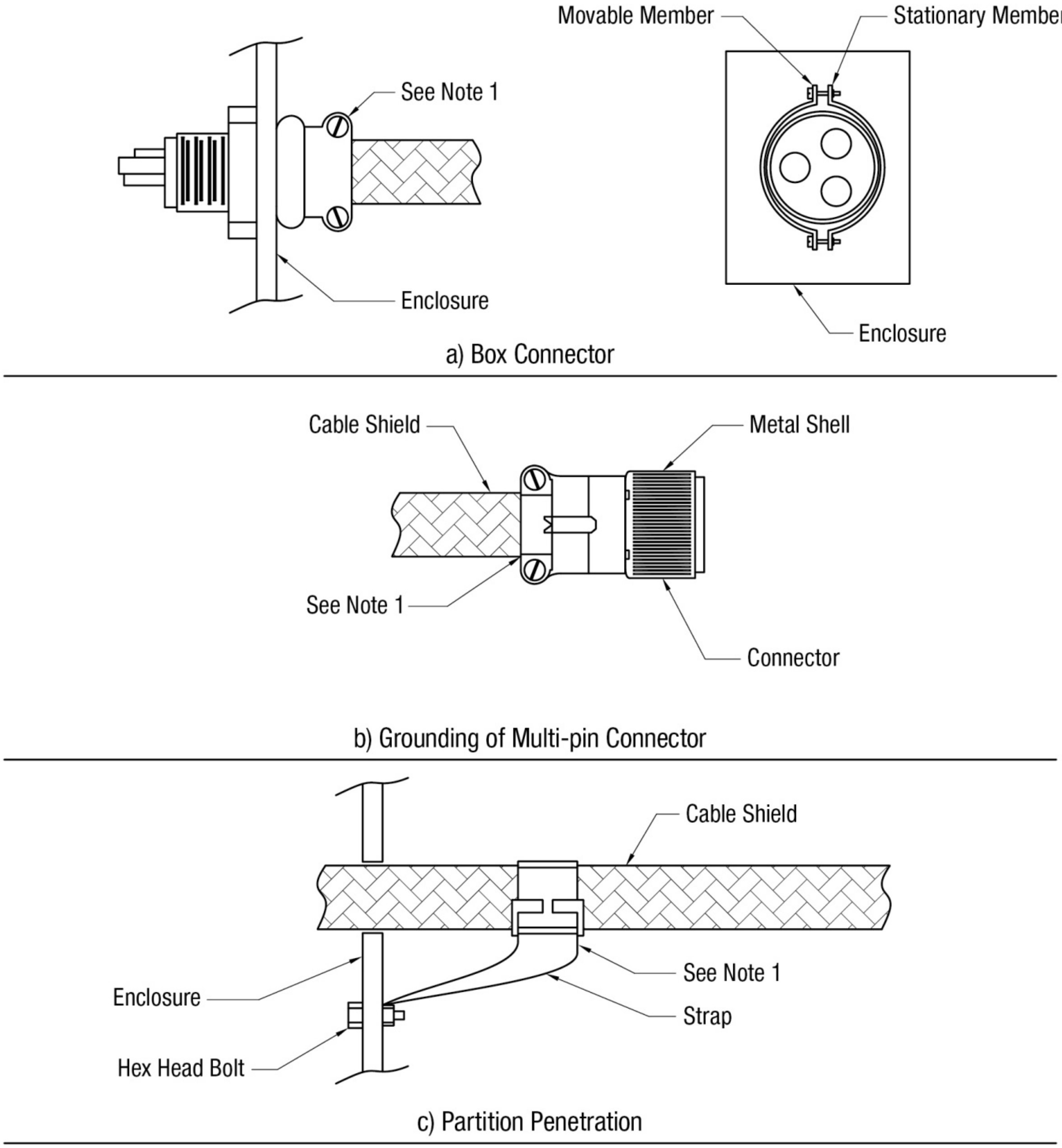
Cables that have an overall shield over individually shielded pairs shall have the overall shield grounded at each end unless otherwise required by the equipment. Grounding through an SPD is permissible if grounding both ends of the conductors degrades system performance. If present, the drain wire shall be grounded in the same manner as the shield.

a. Cable Shields. Cable shields terminated to connectors shall be bonded to the connector shell as shown in Figure 12 (a) or (b). The shield shall be carefully cleaned to remove dirt, moisture, and corrosion products. The connector securing clamp shall be tightened to ensure that a low-resistance bond to the connector shell is achieved along the entire circumference of the cable shield. The bond shall be protected against corrosion in accordance with paragraph 4.2.4.3. The panel-mounted part of the connector shall be bonded to the mounting surface in accordance with paragraph 5.6.6.2.

b. Interruption of Continuity. Where the cable shield continuity is interrupted, such as in a junction box, the shield shall be extended through and grounded at the box. The length of unshielded cable conductors shall not exceed 1 in. Where dictated by constructability constraints, shield pigtails may be longer than 1 in., but shall be as short as possible.

c. Cables Bonded to Penetrated Surfaces. Cables that penetrate walls or panels of cases or enclosures without the use of connectors shall have their shields bonded to the penetrated surface in the manner shown in Figure 12 (c). Overall shields shall be terminated at the outer surface of cases to the maximum extent possible.

d. Overall Shield Grounding. Grounding of overall shields to terminal strips shall be as shown in Figure 13.



Note:

1. Ensure that cable shield is clean and that securing clamp is tightened to provide a suitable ground.

Figure 12. Grounding of Overall Cable Shields to Connectors and Penetrating Walls

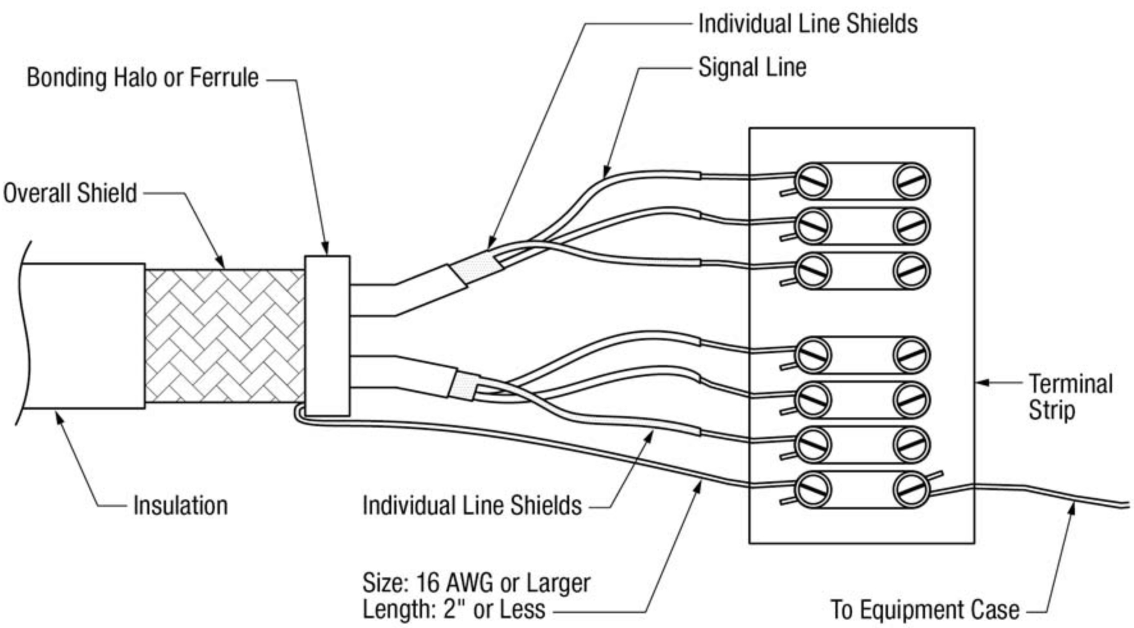


Figure 13. Grounding of Overall Cable Shield to Terminal Strip

4.8.4 Electromagnetic Environment Control

Shielding shall be integrated with other interference control measures such as filtering, wire routing, cable and circuit layout, signal processing, spectrum control, and frequency assignment to achieve the highest operational reliability of the equipment. Implementation procedures necessary to achieve the required filtering and shielding shall be detailed in the control plan described in 5.9.2 to include material requirements, shield configurations, placement and installation limitations, gasket utilization, filter integration, aperture control, bonding and grounding requirements, and wire routing and circuit layout constraints.

4.8.4.1 Space Separation

The design and layout of facilities shall physically separate electronic equipment and conductors that produce interference from other equipment and conductors that are susceptible to interference. The minimum separation distance between power and signal cables shall be in accordance with Table 6.

4.8.4.2 Wire and Cable Routing

The routing and layout of wires, conductors, and cables shall be performed in a manner that does not jeopardize the integrity of the equipment shield. Signals with power level differences of greater than 20 dB shall be routed as far apart as possible. Alternating current power conductors and control lines shall be routed away from sensitive digital or other susceptible circuits. Shielded cables shall be used where required to prevent emissions and/or to provide shielding. Cable shields shall be grounded in accordance with the requirements of paragraphs 4.8.3.2 and 4.8.3.3.

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Table 6. Minimum Separation Distance between Signal and Power Conductors

Condition	Circuit Power Level		
	< 2 kVA	2-5 kVA	> 5 kVA
Unshielded power lines or electrical equipment in proximity to signal conductors in open cable tray or nonmetal raceway.	5 in.	12 in.	24 in.
Unshielded power lines or electrical equipment in proximity to signal conductors in a grounded metal raceway.	2.5 in.	6 in.	12 in.
Power lines enclosed in a metal raceway (or equivalent shielding) in proximity to signal conductors in a metal raceway.	-	3 in.	6 in.

4.8.4.3 Bonding and Grounding of Compartment Shields
All shields shall be grounded. Bonding shall be in accordance with section 4.2.

4.9 Electrostatic Discharge (ESD) Requirements

4.9.1 General
Modern electronic and electronically controlled electrical equipment are susceptible to damage from ESD. The requirements of this section are intended to reduce the frequency and minimize the effects of ESD events. Electronic circuitry that contains miniaturized or solid-state components shall be considered ESD susceptible.

4.9.2 Requirements
NAS electrical and electronic equipment, subassemblies, and components subject to damage from exposure to electrostatic fields or ESD shall be protected in accordance with section 5.8. ESD controlled areas shall be provided for operations, storage, repair, and maintenance spaces used for electrical and electronic equipment or subassemblies that are subject to damage from static electricity or ESD.

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5 DETAILED REQUIREMENTS

5.1 Introduction

This chapter describes detailed performance requirements, which are specific to FAA facility applications, organized by facility special conditions and equipment as follows:

a. Airport Traffic Control Tower (ATCT) Facilities

b. Lightning Protection System – Special Conditions

c. Facility Transient Protection – Special Conditions

d. Single Point Ground System (SPG) – Special Conditions

e. NAS Electronic Equipment – Interface and Procurement Requirements

f. Surge Protection Device (SPD) – Procurement Requirements

g. Electrostatic Discharge (ESD) Equipment – Interface and Specification Requirements

h. Electromagnetic Compatibility Requirements

5.2 Airport Traffic Control Tower (ATCT) Facilities

Figure 14 depicts the elemental relationship of areas located at the top of a typical ATCT. Operation of NAS electronic equipment areas located in the cab, junction, and subjunction levels present a unique set of challenges for implementation of lightning and transient protection. NAS electronic equipment areas are spaces where the equipment is physically located or associated passageways that distribute utilities within the tower. Power and telecommunication distribution systems (NAS supporting utilities) either originate from the base of the tower or an attached base building.

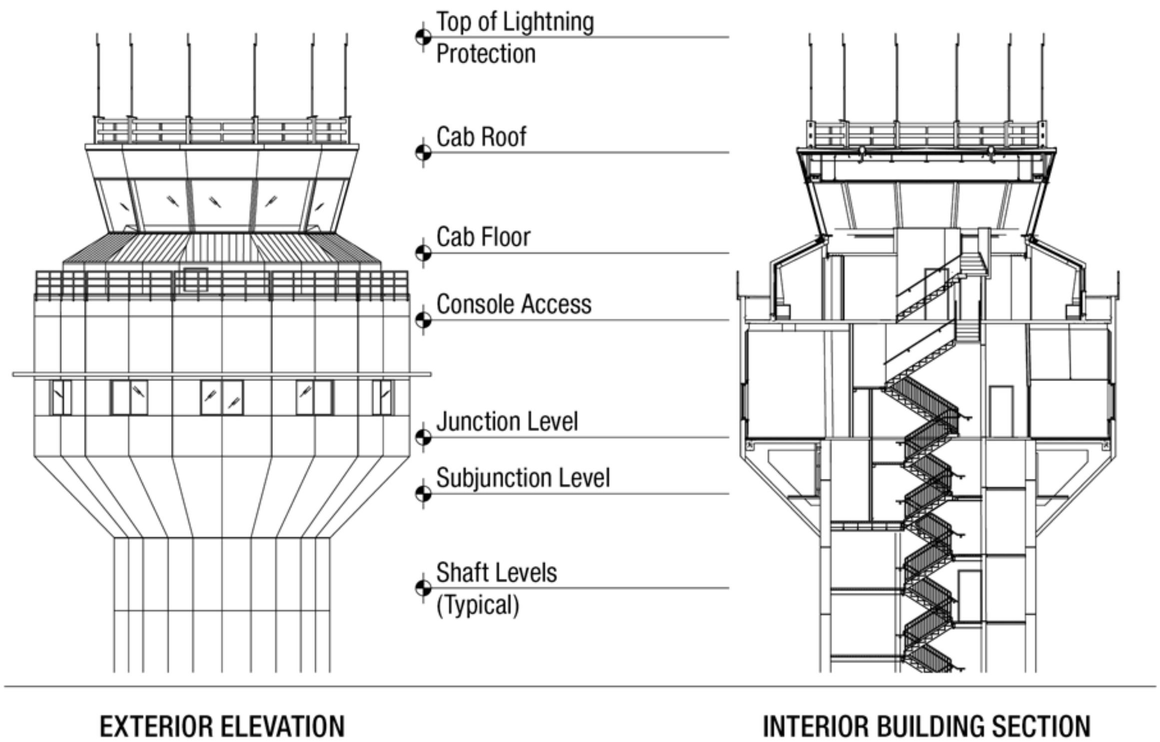


Figure 14. Airport Traffic Control Tower – Typical Floor Levels

5.2.1 General

During lightning strikes, there is a potential difference between the reference voltage at the top of the tower and the base of the tower. It is therefore necessary to reference all systems at the top of the tower to each other and treat this area as a separate facility. The NAS electronic equipment and associated supporting utility distribution system are subject to large electromagnetic fields during a lightning strike. For this reason, special techniques are required to provide an environment that minimizes the damaging effects of lightning. ATCT systems requiring special consideration include:

a. Lightning and Transient Protection

b. Main Ground Connections

c. Power Distribution System

d. NAS Electronic Equipment Areas

5.2.2 Lightning Protection System

Provide lightning protection in accordance with section 4.3, and this section.

5.2.2.1 Common Bonding of Grounded Systems

The lightning protection, electrical, electromechanical, electronic systems, and building structural steel shall be bonded together for safety.

5.2.2.2 Potential Equalization Loop

Provide a continuous potential equalization loop conductor at the following locations:

a. Roof or Roof Parapet. Install a loop conductor within 24 in. of the periphery of the structure. Interconnect air terminals and down conductors to the equalization loop. Any secondary roof area or parts of the structure that extends beyond the upper most roof zone of protection scheme shall be provided with additional air terminals in accordance with NFPA 780.

b. Exterior Platforms, Catwalks, and Personnel Access Areas. Provide a potential equalization loop for platforms that extend beyond the ATCT building perimeter. Interconnect down conductors to the equalization loop.

c. Tower Shaft Intermediate Floor Levels. Install a loop conductor at tower intermediate levels, evenly spaced no more than 60 ft apart, measured from the roof equalization loop. Interconnect down conductors to the equalization loop.

5.2.2.2.1 Horizontal (Side Strike Protection) Air Terminals for Equalization Loop

Provide horizontal air terminals on equalization loops, in addition to the zone of protection scheme, for exterior platforms and catwalks located at the cab, cab roof, or occupied areas along the ATCT shaft. Install the horizontal air terminals positioned at building corners and along the periphery of the loop where required by the lightning protection zone of protection scheme.

***Exception**. Horizontal (side strike) air terminals are not required for equalization loops located at intermediate floor levels of the tower shaft within the zone of protection scheme where there are no platforms for personnel access, or electronic or electromechanical equipment.*

5.2.2.2.2 Connection of Down Conductor to Equalization Loop

The connection method between the down and equalization loop conductors shall be in accordance with paragraph 4.3.5.

5.2.2.3 Number of External Down Conductors for ATCT

MIL-HDBK-419A, Volume II, paragraph 1.3.2.2.2(d), provides that “buildings and structures shall add one down conductor for every 60 ft of height or fraction thereof, but horizontal spacing between down conductors need not be less than 50 ft.”

The number of down conductors shall be based on both the ATCT height and its largest horizontal perimeter dimensions. For the purposes of this document, the above referenced 50-ft dimension is the horizontal distance between down conductors along the largest projected perimeter area. The following guidelines shall be used in determining the number and configuration of external down conductors:

a. External Down Conductors for ATCTs. All ATCTs shall have a minimum of four down conductors. ATCTs greater than or equal to 180 ft above ground level to cab roof shall add one down conductor for every 60 ft of height or fraction thereof above 180 ft. For ATCTs greater than or equal to 180 ft, the number of down conductors may be substituted, but not less than four, by using larger sized individual conductors to achieve equivalent overall conductor cross-sectional area.

   Exception. *Existing ATCTs are exempt from the minimum number of external down conductor requirement, if less than 60 ft above ground level to the cab roof and the horizontal perimeter dimension spacing between down conductors is less than 50 ft. However, when removal of the down conductors is performed as part of a major project, such as when replacing siding of an ATCT, reinstallation shall incorporate the minimum number of down conductors as stated in this paragraph.*

b. Building Structural Steel. Building structural steel is permitted as a substitute for only one down conductor for lightning protection. Concrete encased structural reinforcing bars or precast construction systems are not qualified for use as building structural steel. It is permissible to substitute substantial metal structural elements of buildings for regular lightning conductors where, inherently or by suitable electrical bonding, they are electrically continuous from the air terminal to the earth electrode connection. The structural elements shall have a conducting cross-sectional area, including at the structural connections, at least twice that of the lightning conductor that would otherwise be used. Lightning conductors may be installed on the interior or exterior to the building enclosure. Steel frame buildings enclosed in architectural precast concrete or masonry products shall have external air terminals and roof conductors installed and bonded directly to the structural members to keep the lightning discharge from having to penetrate the masonry shell to reach the frame members. Refer to MIL-HDBK-419A, Volume II, paragraph 1.3.2.2.2(i).

5.2.2.4 Transient Surge Protection

Provide SPDs in accordance with section 4.6 for NAS facility entrance points located at the base building/tower shaft and at the top of the shaft.

5.2.3 Main Ground Connections

A low-impedance connection shall be provided to the EES to ensure good high-frequency grounding during normal operation. Ground connections shall be established in the ATCT as a common point of connection within the facility. Provide ground plates in accordance with paragraph 4.7.2 and as specified herein.

5.2.3.1 ATCT MPG Configuration – Preferred Method

Refer to Figure 15 for MPG configuration topology and connection requirements. A main ground plate shall be established on the lowest level with electrical, electromechanical, or electronic equipment serving the ATCT cab. Grounding systems located at or above this level of the ATCT shall be connected to this main ground plate. Provide a combination of conductors, in accordance with Table 7, and two parallel paths as indicated in Figure 15. Install each conductor path within separate chases located in the tower shaft. Conductors shall be routed continuously between ground plates without sharp bends, loops, or kinks.

Recombine risers to an MPG plate at each maintenance level of the ATCT shaft. These conductors shall be mechanically bonded to the main ground plate and the base plate. Connect base plate(s) exothermically to the EES with the same number and size of conductors used for the riser conductors in accordance with Table 7.

5.2.3.2 ATCT MPG Configuration - Alternative Method

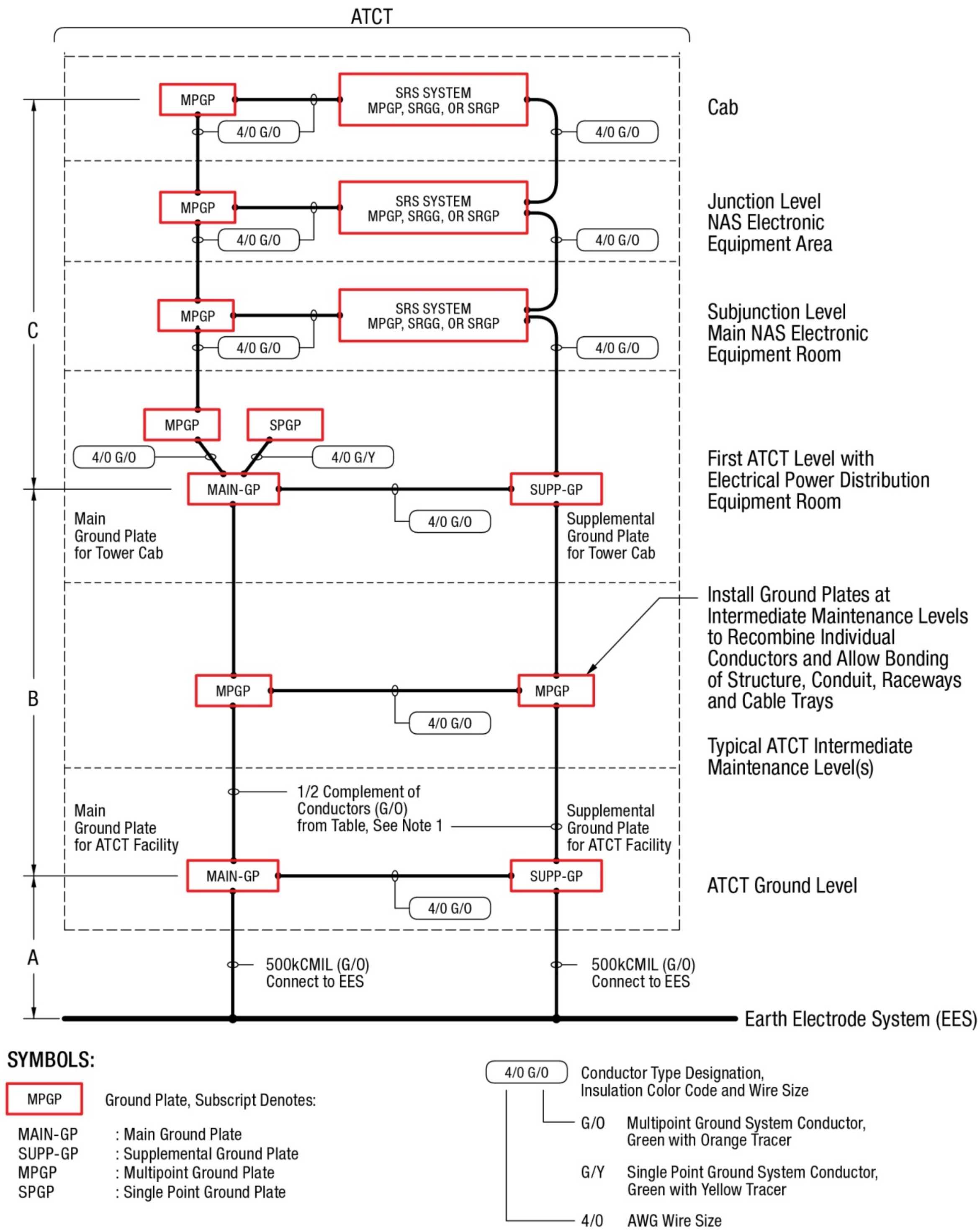
Refer to Figure 16 for MPG configuration topology and connection requirements. A main ground plate shall be established on the lowest level with electrical, electromechanical, or electronic equipment serving the ATCT cab. Grounding systems located at or above this level of the ATCT shall be connected to this main ground plate. Provide a combination of conductors, in accordance with Table 7, and connect this main ground plate to a plate at the base of the ATCT. These conductors shall be routed continuously from the main ground plate to the base plate without sharp bends, loops, or kinks.

Table 7. ATCT MPG Configuration – Parallel Conductor Complements

Electrical Distance from EES to Farthest MPG Plate Measured in Feet, See Note 1	Two (2) Conductor (kcmil)	Three (3) Conductor (kcmil)	Four (4) Conductor (kcmil)	Five (5) Conductor (kcmil)	Six (6) Conductor (kcmil)	Number of 4/0 (AWG)
Up to 250	500	350	250	4/0	-	5
251 to 300	600	400	300	250	4/0	6
301 to 350	700	500	350	300	250	7
351 to 400	800	600	400	350	300	8
401 to 450	900	600	500	400	300	9

Note:

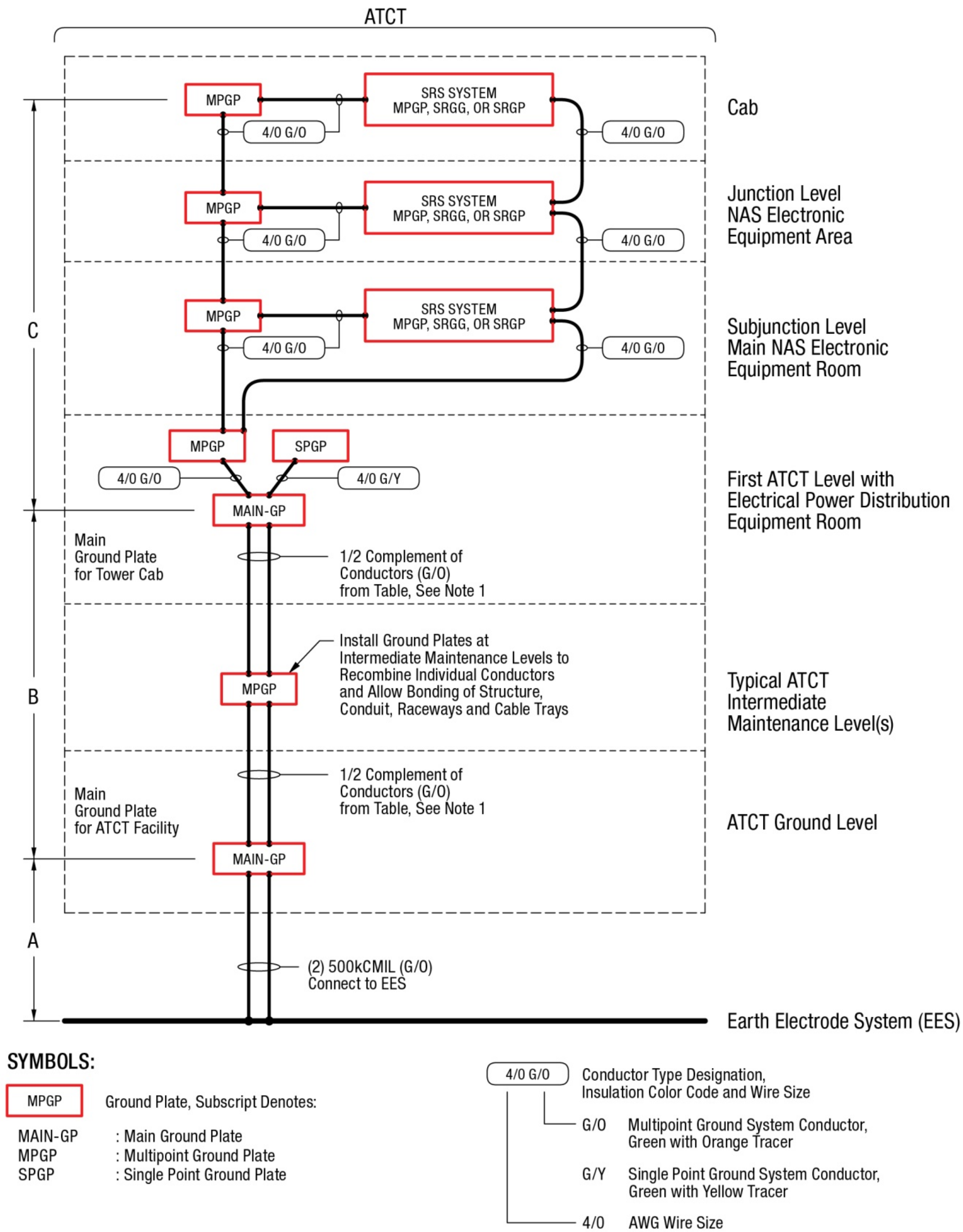
1. Refer to Figure 15 and Figure 16 for conceptual MPG configurations.



Note:

1. Total height calculation (A+B+C) shall be used to determine cable size parameter indicated in Table 7.

Figure 15. Typical Electronic Equipment Grounding Riser Diagram for ATCT (Preferred Method)



Note:

1. Total height calculation (A+B+C) shall be used to determine cable size parameter indicated in Table 7.

Figure 16. Typical Electronic Equipment Grounding Riser Diagram for ATCT (Alternative Method)

5.2.4 Power Distribution System

Provide power distribution for ATCT in accordance with section 4.5 and as specified herein.

a. NAS Electronic Equipment Power Loads. Provide separately derived power sources for NAS electronic equipment loads when the ATCT height is greater than 100 ft measured to the cab floor level.

b. Separately Derived Power Systems. The separately derived systems shall be grounded in accordance with the requirements of NEC article 250 and paragraph 4.5.2d at the first downstream disconnecting means or overcurrent device. This point of connection is mandated to facilitate the effective installation of an SPD.

c. Surge Protection. Provide SPDs, in accordance with paragraph 4.6.2. The SPD shall be installed on the load side of the first downstream disconnecting means or overcurrent device of each separately derived system. The ground bus at the first disconnecting means or overcurrent device shall be bonded to the main ground plate established in accordance with the requirements of paragraph 5.2.3. This connection is in addition to the grounding electrode conductor requirements of NEC article 250.

d. Bonding of Metallic Piping Systems. The interior metallic piping supply systems located at the top and bottom of the ATCT mechanical piping chase, such as water, plumbing, and mechanical piping systems, shall be bonded to the main ground plates established in accordance with the requirements paragraph 5.2.3. If interior metallic piping systems are not located near the main ground plate, bond interior piping to the nearest MPGP. This connection is in addition to the bonding requirements of NEC article 250.

5.2.5 NAS Electronic Equipment Areas

Provide grounding and bonding for NAS electronic equipment in accordance with section 4.7 and paragraph 5.2.3 and as specified herein.

5.2.5.1 ATCT Building Structural Steel Bonding Requirements

Structural steel columns and beams of the ATCT shall be bonded together and to the EES in accordance with paragraph 4.5.6 and as specified herein.

The design of the ATCT shaft shall make provisions to ensure that all concrete reinforcing steel used throughout the shaft is electrically bonded together, continuously, horizontally and vertically, and to the EES.

Horizontal metal transitions, such as floors, stairs, and walkways shall be bonded to the ATCT structural steel members or concrete reinforcing steel bars at every level. Elevator support structures shall be bonded to horizontal metal transitions and to the EES. All bonding jumpers shall be a minimum 2 AWG copper conductor.

5.2.5.2 Signal, Communications, Axial Cables, and Control Line Protection

Transient protection shall be applied at each end of vertical cables routed between the equipment room located near the top of the ATCT and the associated base building. Cables between the tower cab and equipment room areas shall be protected in accordance with paragraph 4.6.3. Both facility and equipment levels of protection shall be provided for these lines. Enclosing metallic cabling in ferrous conduit or the use of all dielectric fiber optic cable can significantly reduce the threat of lightning related damage to ATCT and base building circuits.

5.2.5.3 Signal Reference Structure

An SRS shall be constructed in accordance with applicable requirements of paragraph 4.7.3, including the cab and other areas at the top of the ATCT that contain electrical, electromechanical, or electronic equipment serving the cab.

a. SRGG Installation. The main and supplemental ground plates and building steel may be used to establish equipotential bonding for the SRGG perimeter loop conductor in lieu of the EES for facilities located at the top of the ATCT. Provide one connection between the perimeter loop conductor to the main and supplement ground plates. Provide at least two additional connections between the perimeter loop conductor and building steel.

5.2.5.4 Floor Coverings for Electronic Equipment and Operational Areas

Floor coverings for cab and areas serving the cab shall either be tile or carpeting and shall be composed of static dissipative material. The floor coverings and installation shall be per the manufacturers' specifications and paragraph 5.8.9 and shall be connected to a component of the SRS, but not to the SPG system.

5.2.5.5 Single Point Grounding

SPGs, if required, shall be constructed in accordance with section 5.5. SPGs and independent ground systems required by equipment manufacturers shall be bonded to the ATCT main ground plate, located at the top of the tower, in accordance with the requirements of paragraph 5.2.3. The SPG shall be constructed in a radial configuration and not form a loop.

5.3 Lightning Protection System – Special Conditions

5.3.1 General

This section describes facilities or systems that require additional design considerations for installation of lightning protection systems. The following applications are addressed:

a. Antenna Towers

b. Antenna Protection

c. Tower Guying

d. Waveguide, Axial Cable, and Conduit Grounding

e. Staircase/Ladder Protection

f. Facilities without Buildings or Antennas

g. Lightning Protection for Fences and Gates

h. Lightning Protection for Photovoltaic Solar Arrays

5.3.2 Antenna Towers

5.3.2.1 Number of Down Conductors for Towers

Towers consisting of multiple, parallel segments or legs that are erected on a single pad or footing not over 9 ft^2 in area are considered pole type towers. Other towers shall have at least two down conductors. Large towers, such as radar towers, shall have one down conductor per leg. Down conductors on towers shall be bonded to each tower section. Down conductors shall be routed down the outside of the legs wherever possible and secured at intervals not exceeding 3 ft.

5.3.2.2 Pole Type Towers

Pole type towers shall be protected by at least one air terminal and have at least one down conductor. This is to provide a zone of protection for antennas located on the tower.

5.3.2.3 Towers without Radomes

Protection shall be provided for large radar antennas by extending structural members above the antenna and mounting the air terminal on top as shown in Figure 17 unless directed otherwise by the radar system OPR. Structural members shall be braced as necessary and shall not be used as part of the air terminal or down conductor. The air terminal shall be supported from structural framing and shall have a UL listed fitting on its base. The down conductor from the air terminal shall be connected to a perimeter conductor that forms a loop around the perimeter of the tower platform. Down conductors shall extend from the perimeter conductor to the EES. Each air terminal shall be provided with at least two paths to the ground. Conductors shall be in accordance with NFPA 780. Tower legs shall be bonded to the EES with a 4/0 AWG copper conductor exothermically welded at each end. This bonding conductor shall be either a separate conductor, or permitted to be a part of the down conductor, as described in paragraph 4.3.5.1.

5.3.2.4 Radomes

Radomes shall be located within a zone of protection established according to the 100-ft radius "rolling sphere model" described in NFPA 780. This protection is provided by air terminals mounted on the radome, or by air terminals or catenary wires mounted independently of the radome. Air terminals mounted on the radome must have two paths to the EES. A perimeter conductor shall be provided at the radar antenna deck level.

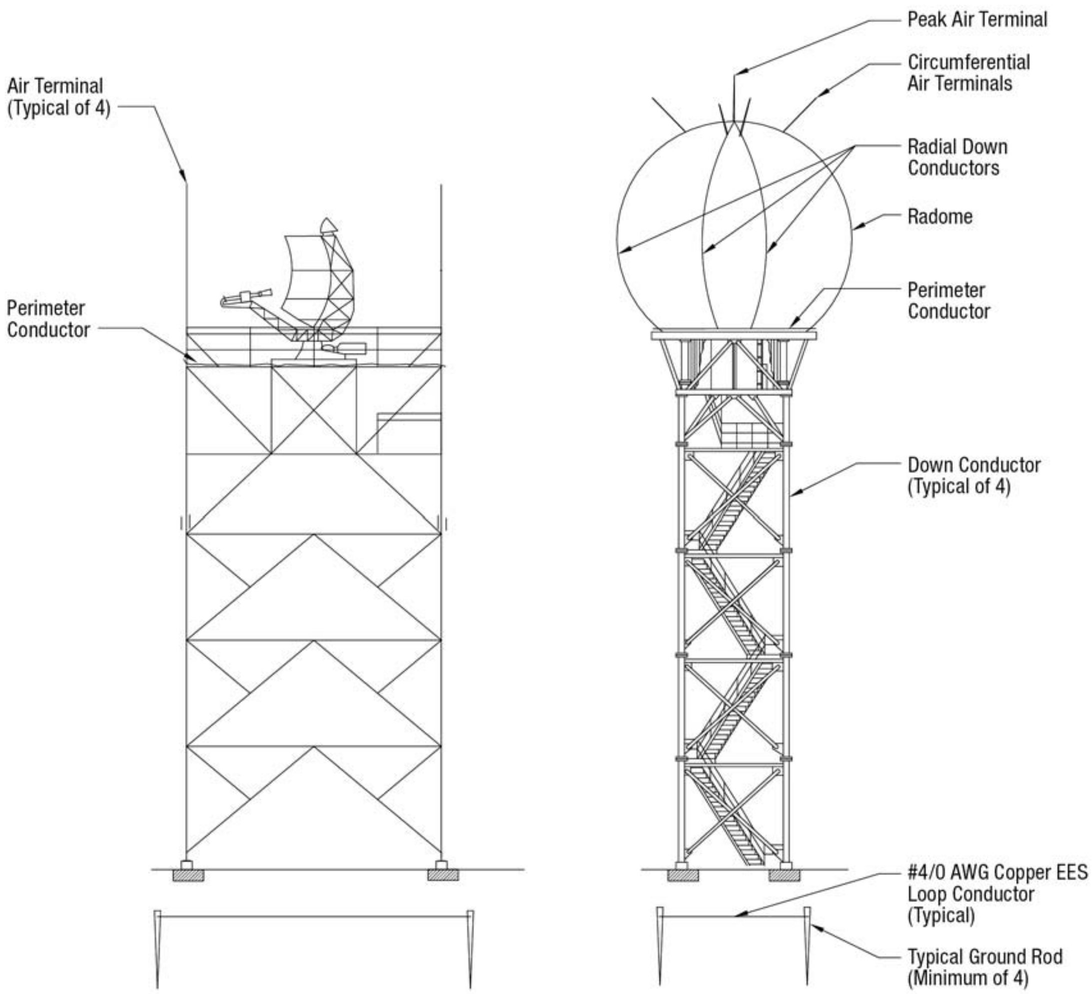
Lightning protection systems for standalone radomes shall be designed and installed in consultation with the OPR of the radar system and the OPR of this document. Paragraph 5.3.2.5 shall be used as guidance in developing lightning protection systems for these radomes.

5.3.2.5 Towers with Radomes

Lightning protection systems for towers with radomes shall be designed and installed in consultation with the OPR of the radar system and the OPR of this document.

Towers with radomes shall be protected with a minimum of one 2-ft-long air terminal at the peak and four or more air terminals equally spaced along the circumference of the radome and oriented perpendicular to the radome. The spacing and quantity of circumferential air terminals shall be adjusted if the antenna pattern is affected, but their sizing, position, and height shall establish a protection zone as specified in paragraph 5.3.2.4. Circumferential air terminals shall be interconnected with main-sized conductors.

Radial down conductors, as indicated in Figure 17, shall be connected to the air terminal on the peak. The radial down conductors shall also be connected to the perimeter conductor that forms a loop around the base of the radome. Radial down conductors on the radome shall be routed from the air terminal at the peak of the radome, in a path following the contour of the radome, to a connection with the circumferential air terminals and then to a connection with the perimeter conductor as shown in Figure 17. Deviations from the shortest possible path are permitted where nearfield radar analyses determine that interference from the conductors will degrade the performance of the radar. Bends in the radial down conductors on the radome shall maintain the largest possible radii and in no case shall be less than 12 in. One down conductor per leg shall connect the perimeter conductor at the base of the radome to the EES. Down conductors shall be bonded to each leg section. Tower legs shall be bonded to the EES with a 4/0 AWG copper conductor exothermically welded at each end. This bonding conductor can be the same conductor required in paragraph 4.3.5.1.



Notes:

1. Bond down conductors to each tower leg section. Exothermically weld down conductor to a 4/0 AWG copper conductor above grade. Route 4/0 AWG conductor though a 1-in. PVC conduit around the foundation concrete pier to 12 in. below grade and connect the conductor to the EES.
2. Where a radome has an electrically continuous frame, the framing may be used in lieu of the lower air terminals.
3. All lightning protection connections shall be free of paint and galvanizing. Scrape all steel free of surface contaminants prior to making exothermic welds or mechanical connections.

Figure 17. Lightning Protection for Radomes and Radar Antenna Platforms

5.3.3 Antenna Protection

Air terminals shall be located to protect structural towers and buildings, and antennas mounted to towers and on buildings.

Most antennas throughout the FAA can be installed or engineered to be installed within the lightning zone of protection. However, there are select times where engineered solutions cannot be easily installed. Antennas may be deemed sacrificial if either of the following conditions exist:

a. A 20 foot air terminal (or air terminal installed on a support with the combined height of 20 feet) does not provide proper zone of protection; or

b. Lightning protection for an antenna will cause radiation pattern distortion.

Sacrificial antennas shall comply with the following:

a. Bonding and surge protection in accordance with 4.6.3, 5.3.5, and 5.4.3.2; and

b. The antenna or base is bonded to the lightning protection system.

All sacrificial antennas must be identified by the designer/program office to the SSC (e.g. ASSC). An SRM is one established method that is permitted to meet this requirement.

5.3.4 Tower Guying

Provide grounding and bonding for tower guying in accordance with TIA-222.

5.3.5 Waveguide, Axial Cable, and Conduit Grounding

Waveguide, axial cable, and conduit located on the tower and feeding into the facility shall be bonded to a bulkhead ground plate mounted on the tower and configured in accordance with 5.4.3.2.

a. <u>Overhead Cable Runs</u>. Bulkhead plate bonding connections shall be located above the cable path at transition/turning point (90 degree bend point) near the tower's base where the cable transitions horizontally from the tower and enters the facility. Above-ground ferrous conduit located at the facility entrance shall be bonded in accordance with 5.4.3.1.1.

b. <u>Underground Cable Runs</u>. Bulkhead plate bonding connections shall be located above the cable transition point where the cables enter the facility conduit riser. If cables enter ferrous conduit, the conduit shall be bonded to the EES in accordance with 5.4.3.1.

5.3.6 Staircase and Ladder Protection

The metallic staircase or ladder access to the tower shall be exothermically bonded near its base to the EES with a 4/0 AWG copper conductor installed in a location that avoids accidental tripping or striking hazards that could result in personnel injury. Where the staircase or ladder material is not thick enough for an exothermic weld, provide a two-hole hydraulically crimped connection. To ensure electrical continuity, sections of stairs or platforms that are not welded together shall be connected by bonding jumpers.

5.3.7 Lightning Protection for Facilities without Buildings or Antennas
Small facilities such as Runway Visual Ranges (RVR) commonly are built without buildings or antennas. Since loss of these facilities can have a significant impact on NAS operations, these facilities shall be included within a zone of protection with either air terminals or overhead catenary wires.

5.3.8 Lightning Protection for Fences and Gates
General airport fencing is not subject to the requirements of this standard. Non-FAA owned fencing that is adjacent to FAA facilities shall be protected as mandated by agreement with the owner of the fencing.

Fences shall be constructed using electrically conducting materials (for example, chain link fabric, metal crossbar, stranded wire, etc) using metal posts that extend a minimum of 2 ft below grade into a concrete base. Metallic fence fabric with nonconductive coatings is not permitted, except where corrosive climatic conditions require corrosion protection.

5.3.8.1 Fence Grounding
Provide fence grounding in accordance with the following:

a. Fence Post Grounding. Provide a ground rod adjacent to the fence post. Locate ground rods at horizontal linear spacing intervals not greater than 100 ft along the perimeter fence line. Provide a 4/0 AWG bare stranded copper conductor, exothermically welded to each ground rod and fence post.

b. Ground Rod Installation. Ground rod material and installation parameters shall be in accordance with paragraph 4.4.4.1. If soil conditions will not permit installation of ground rods, provide ground dissipation plate(s) in accordance with paragraph 4.4.4.3.

c. Fence Gate. Provide a 1-in. by 1/8-in. flexible tinned copper bond strap or an insulated 4/0 AWG flexible welding type copper conductor connected between the gate and adjacent fence post. Exothermic welding is recommended for these connections. Install the bonding strap between the gate and post so it will not limit full motion of a swing or slide gate.

d. Fence Gate Post. Provide a ground rod adjacent to each gate post. Install a 4/0 AWG bare stranded copper conductor, exothermically welded to the ground rod and gate post. Locate the post connection at not greater than 1-ft above grade. Interconnect ground rods located between the gate opening with an exothermically welded 4/0 AWG bare copper conductor buried below frost depth, but not less than 18-in. below ground.

e. Fence Gate Fabric. Provide a horizontal 6 AWG bare stranded tinned copper conductor threaded continuously through the gate fabric and mechanically bonded to the gate vertical support rails.

f. Fence Security - Barbed Razor Wire. Bond security wires to the fence post using 6 AWG bare stranded tinned copper conductor and UL listed bonding connectors. Bond across terminations in the security wire using a short piece of the security wire material and UL listed bonding connectors at the same locations in 5.3.8.1 (a), (c), and (d).

g. Fence Wire Fabric - Chain Link. Attach metallic fence fabric to fence posts with wire ties of the same material.

h. Proximity to a Facility EES. Portions of a fence that are located within 22 ft of a facility EES shall be bonded to that EES with a 4/0 AWG bare copper conductor exothermically welded to a fence post ground rod. Connections shall be made at a maximum spacing of 100 ft, with a minimum of two connections.

See Figure 18 for illustration of fence grounding installation methods.

5.3.8.1.1 Architectural Style Fences

Where architectural fences are installed, bond the nearest post with a two-hole hydraulically crimped lug to the ground rod. The security barbed razor wire bonding requirement does not apply to architectural fences.

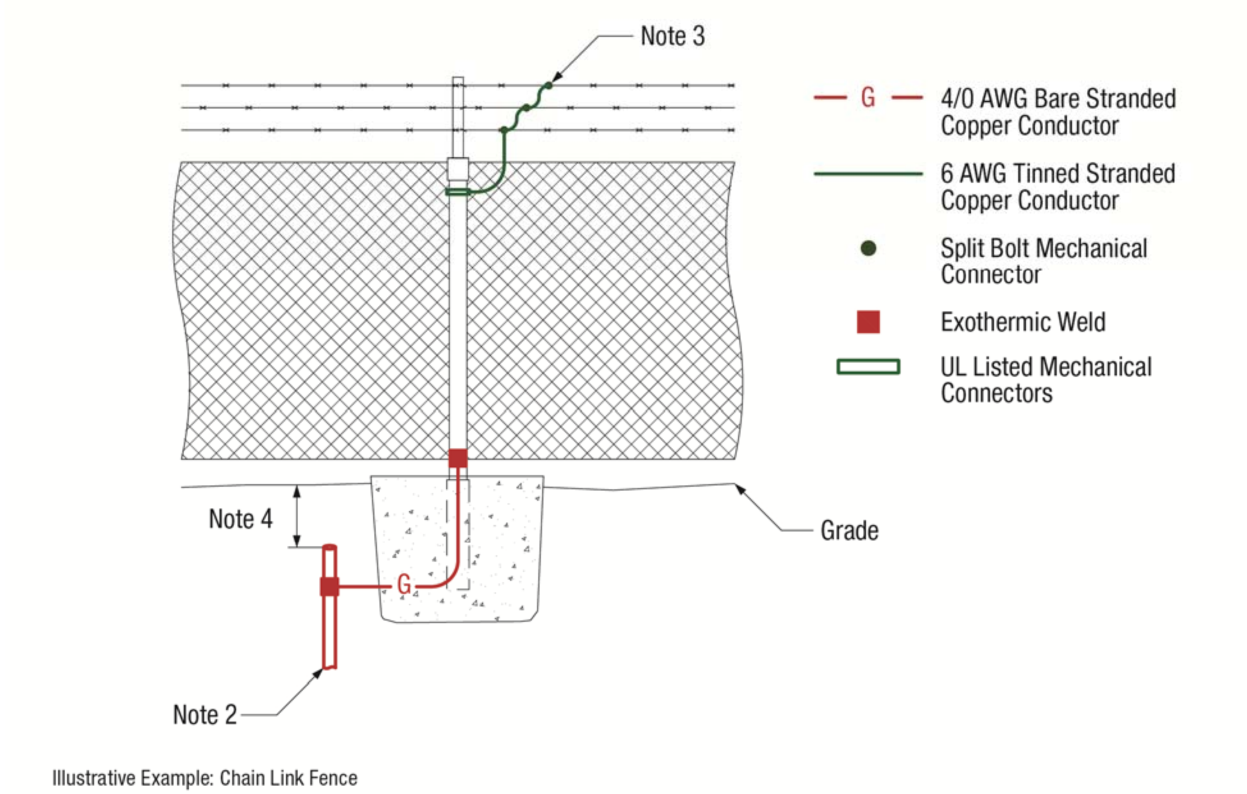
5.3.8.2 Fences Crossed by Overhead Power Lines

At locations where overhead power lines cross a fence, bond a fence post no more than 20 ft on each side of the crossing to a ground rod with a bare 4/0 AWG copper conductor. Bond the fence fabric at the top, middle, and bottom of the fence, and bond each strand of security wire placed above the fencing fabric to the grounded post with a bare 6 AWG tinned copper conductor. Where cross-bars or stranded wire is used to support the fence posts, bond the cross-bars or wire supports to the posts.

These connections shall be located 20 ft on side of the overhead power line crossing.

5.3.9 Lightning Protection for Photovoltaic Solar Arrays

Lightning protection for photovoltaic solar arrays shall be provided in accordance with NFPA-780.



Notes:

1. Diagram depicts elemental parts of a typical fencing grounding and bonding installation. Other architectural style fence configurations are possible.
2. Install 10 ft long by 3/4 in. diameter copper clad ground rods at all corners, gate posts, and at intervals not to exceed 100 feet. Exothermically weld each ground rod to the post.
3. Mechnically bond each strand of security wire to the fence post at all corners, gate posts, and at intervals not to exceed 100 feet.
4. 12 in. minimum below grade, but not less than frost depth.

Figure 18. Fence Grounding

5.4 Facility Transient Protection – Special Conditions

5.4.1 General

This section describes additional design considerations for facility transient protection against induced currents from nearby, direct, or indirect lightning strikes. All metallic conduits, conductors, and cables in NAS operational facilities can be subject to currents induced by nearby lightning strikes. These induced effects can adversely affect the operation of sensitive electronic equipment.

5.4.2 Existing Metallic Conduit, Conductors, and Cables

Unless not approved by the facility manager, all unused conduits, conductors, and cables shall be removed.

For any remaining unused items, the voltage differential between ends shall be minimized by the following bonding methods:

a. <u>Unused Metallic Conduits</u>. Metallic conduits shall be bonded to adjacent grounded metalwork at both ends. If not directly bonded, the connection shall use a minimum 6 AWG jumper not longer than 18 in.

b. <u>Unused Conductors and Cables</u>. These conductors and cables shall be bonded to adjacent grounded metalwork at both ends. Multiple unused conductors shall be grouped together and bonded to the adjacent metalwork, directly or with a bonding jumper.

   <u>Exception</u>*. Bonding is not required for unused conductors of a structured cable system and vertical risers installed for spare purposes for the following conditions:*

   1. *Vertical cable risers are located no more than 50 ft from grounded metalwork.*
   2. *Cable circuit length totals are not more than 300 ft and do not pass between facilities.*
   3. *Cable circulating currents are present; installation of a SPD at one end of the cable may be used for this condition.*

c. <u>Cables With Shields</u>. Unused shielded cables shall be bonded to adjacent grounded metalwork at both ends.

5.4.3 Electromagnetic Shielding for Lines, Conductors, and Cables

5.4.3.1 Facility Entrance Conduit

Direct routed conductors and cables, both buried or above ground, shall enter the facility through a minimum of 10-ft ferrous RGS conduit at the exterior face of the building. For above-ground conditions, provide a minimum 10-ft ferrous RGS conduit on the exterior face of the facility at the entrance point. Entrance conduits shall be bonded to the EES with a bare copper stranded conductor, 2 AWG minimum. This entrance conduit, if buried, shall extend a minimum of 5 ft beyond the EES. Entrance conduits can be bonded below or above grade.

<u>Exception</u>*. Power feeders maintained by and installed to the requirements of the electric utility provider are exempt from the facility entrance RGS requirement.*

5.4.3.1.1 Above-Ground Conduit Entrance to Facility

At the conduit entrance point, a bonding connection shall be made either to the EES or to a bulkhead connector plate that is bonded to the EES in accordance with paragraph 5.4.3.2. If neither of these bonds is feasible, the bond shall be made to the main or supplemental multipoint ground plate. Provide a minimum 2 AWG stranded copper conductor using exothermic welds or UL-listed pressure connectors for this connection.

5.4.3.1.2 Conduit Joints and Fittings

Conduit joints and fittings shall be electrically continuous with bonding resistance of 5 mΩ or less between joined parts. Conduit enclosing signal, control, status, power, or other conductors to electronic equipment shall be terminated using conductive fittings to their respective junction boxes, equipment cabinets, enclosures, or other grounded metal structures.

5.4.3.2 Metal Bulkhead Connector Plates

A metal bulkhead connector plate shall be provided where overhead axial-type cables and waveguides enter the facility. The bulkhead connector plate shall be mounted on the outside surface of the facility or inside the facility within 2 ft of an exterior wall.

a. <u>Bulkhead Plate Dimensions</u>. Ground plates shall be 1/4-in. thick copper or aluminum, and shall have the required number and type of feed-through connectors for axial cable terminations. Plates shall have adequate surface area for bonding all components, such as waveguides, cable shields, and conduits, plus at least two spare positions.

b. <u>Bulkhead Plate Connections</u>. Provide either hydraulically crimped two-bolt-hole style terminal lugs or exothermic welds for conductor connections to the ground plate. Bonding jumpers shall be as short as possible.

c. <u>Cable Shields</u>. Cable shields shall be bonded and grounded, except where the shield must be isolated for proper equipment operation. If external and internal cables are of different sizes, the changeover in cable size is permitted by feed-through connectors at the plate.

Bulkhead plates shall be bonded to the EES with a minimum 4/0 AWG copper cable, color-coded green with a red tracer. When the bulkhead connector plate is located within 6 ft of the building steel, the bulkhead plate shall be connected to the building steel with a 4/0 AWG insulated copper conductor, color-coded green with a red tracer. The building structural steel shall be bonded to the EES using exothermic welds.

Axial type cables, waveguides, and conduits that are not directly bonded to the EES shall be bonded to bulkhead plates with a minimum 6 AWG bonding jumper. The waveguide bonding cable can be connected to the bulkhead waveguide flange with a ring terminal specifically sized for the application. Conduits shall be bonded with a UL-listed U-bolt bonding connector. Axial cable shields shall be bonded with bonding kits sized for the specific cable type. Where SPDs are installed for axial cables, they shall be installed on the antenna or surge side of the metal bulkhead plate. The SPD ground bus bar shall not be connected to the lightning protection system.

Where a bulkhead plate is installed on top of an ATCT, then the ground conductor can be bonded to building steel as opposed to the EES. Reinforcing bars shall not be used in lieu of building steel.

Where a bulkhead plate is installed on top of a building or base building and the path is longer than a tenth of the difference between building steel and the EES (i.e. building steel is 5 feet away and the EES is more than 50 feet away), then the ground conductor can be bonded to building steel. Reinforcing bars shall not be used in lieu of building steel.

5.4.3.3 Facility External - Buried Power Cables and Conductors

Buried external power cables and conductors shall have magnetic shielding to prevent damage from coupling of transient currents due to lightning or other electrical sources. This shielding shall be provided by a ferrous metal sheath, ferrous armor, or ferrous RGS conduit.

Cables are permitted to be installed in metallic or nonmetallic conduit where permitted by the NEC. When a conduit is not used for installation of buried cables, the cables shall be identified for direct earth burial (DEB).

Ferrous shielding is recommended for portions of buried power cables and conductors located beyond 300 ft cable length from the facility entrance point. Facility entrance surge protection shall be in accordance with paragraph 4.6.2.1.

5.4.3.3.1 Armored DEB Cables

Steel armor is the preferred assembly for Armored DEB cables. DEB cable armor shall be bonded to the EES with a 2 AWG conductor prior to entry into a facility or where transitioning to conduit.

DEB cable armor shall also be bonded to the main or supplemental ground plate. If bonding to the main or supplemental multipoint ground plates is not feasible, the armor shall be bonded to the electrical ground bus located at the SDM.

If armor is continued to the electronic equipment, bond the cable armor to the equipment MPG plate.

When the electronic equipment is required to be isolated, bond the cable armor to the equipment SPG plate in accordance with section 5.5.

For initial cable installations, bond resistance shall be less than 5mΩ between joined parts. Complete cable replacement is not required if only a short length of the installation does not meet this requirement.

5.4.3.3.2 Guard Wires

A 1/0 AWG bare copper stranded guard wire shall be provided for buried cables and conductors not routed in ferrous conduit, except as noted below.

Exception. *Guard wires are not required for penetration under runways, taxiways, or topographical features or for 15 kV concentric neutral power cables constructed in accordance with FAA-C-1391d, paragraphs 5.5.7 and 5.5.8. This exception does not apply to concrete-encased PVC duct bank with communication, data, or control cables or to spare ducts that do not contain a corrugated innerduct reserved exclusively for fiber optic cables.*

The guard wire shall be configured as follows:

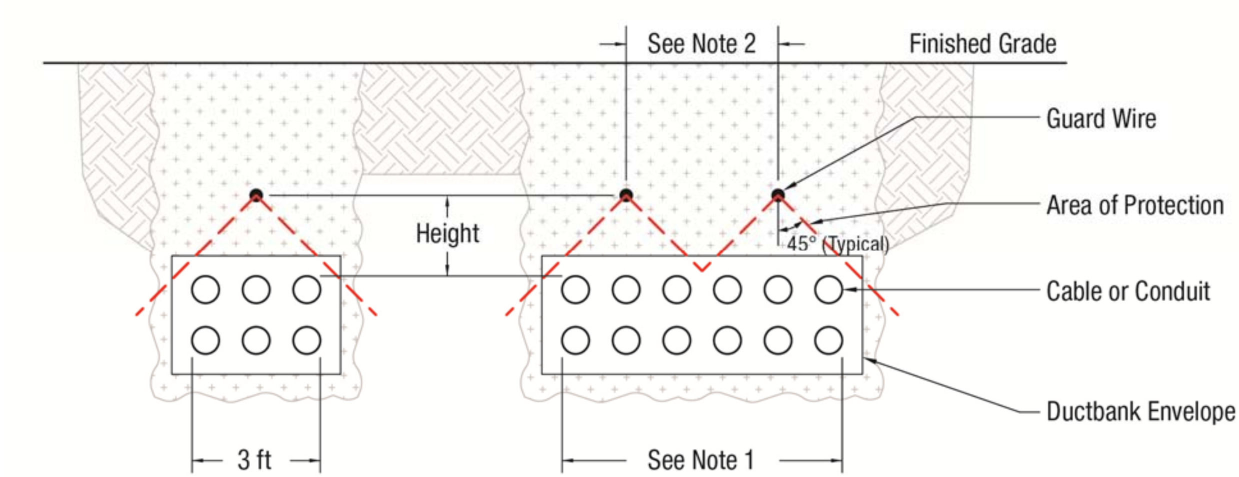
a. Location. The guard wire should be located at least 8 in. below the finished grade, at minimum height of 10 in. above the cable or cable ductbank, and shall run parallel to the cable or cable ductbank path that is being protected.

b. Number of Wires. Provide one guard wire when the width of the cable ductbank is less than 3-ft wide. Provide additional parallel guard wire runs for cables or cable ductbanks wider than 3 ft, in accordance with the Area of Protection criteria. The guard wires should be spaced approximately 12-in. apart to provide an area of protection for the cable ductbank.

c. Area of Protection. This is the protected area encompassed within a 45 degree zone on either side of the guard wire as illustrated in Figure 19.

d. Bonding to EES. Guard wires shall be bonded to the EES at each end, and to ground rods located at approximately 90-ft intervals along the guard wire path using exothermic welds. The spacing between ground rods must vary by 10 to 20 percent to prevent resonance. Install the ground rods approximately 6 ft on either side of the ductbank trench.

e. Airfield Runway Lighting. Where the cable or cable ductbank runs parallel to the edge of a runway, the ground rods shall be located at least 10 ft clear of the navigation lights in the direction of open available space away from the runway or lighting pathways.



Notes:

1. Provide additional parallel guard wire runs for cables or cable ductbanks wider than 3 ft.
2. The spacing intervals between the center lines of the guard wires should not exceed twice the height distance between the guard wire and ductbank.

Figure 19. Buried Guard Wire Detail for Underground Cables or Cable Ductbanks

5.4.3.3.3 Buried Landlines

The preferred type of buried landline that represents best engineering practice is fiber optic type. Fiber optic cable does not require electromagnetic shielding and is exempt from these requirements.

Metallic buried landlines that carry NAS critical, essential, or mission support services to a facility shall have a ferrous shield or be enclosed in ferrous RGS conduit. Ferrous shielding is recommended for portions of these buried landlines located beyond 300-ft cable length from the facility entrance. Facility entrance surge protection shall be provided for these landlines in accordance with paragraph 4.6.3.

5.4.4 Balanced Pair Cables

When possible, shielded circuits should be provided for signal and control circuits routed external to electronic equipment. Balanced pair cables shall be two-conductor circuits.

5.4.5 Fiber Optic Cable

When possible, fiber optic cables should be used in lieu of metallic cables. Fiber optic cables are inherently not susceptible to electromagnetic interference (EMI) or the induction fields produced by lightning, and are not required to be installed in ferrous conduit or have conductive armor for shielding. The use of fiber optic cables without a conductive shield or armor is permitted. Suppression components are not required for fiber optic cables.

a. Facility Entrance. The conductive armor of external fiber optic cables at the facility entrance point shall be bonded to the EES. Use 2 AWG bare copper conductor when bonding directly to the EES. When bonding connection to the EES uses an SPD, the

SPD bonding conductor shall be a 4 AWG stranded copper conductor insulated green with an orange tracer.

b. Facility Cabling. When the cable is internal to the facility and includes metallic electrically conductive sheaths or strength members, the sheaths shall be grounded to any SRS. When the electronic equipment is required to be isolated, bond the cable armor to the equipment SPG plate in accordance with section 5.5. To prevent circulating ground currents in the cable armor, an SPD located at one end of the cable may be used for grounding.

c. Transmitter and Receiver Modules. Fiber optic transmitter and receiver modules shall be contained in ferrous enclosures and bonded to the nearest SRS. Penetrations of the equipment enclosures shall be gasketed or constructed to limit RF coupling. SPDs for the metallic signal and power circuits shall be installed as equipment level protection at the fiber optic receiver or transmitter equipment entrance, and bonded to the equipment enclosure chassis. The transmitter and receiver modules shall have 90 dB of attenuation against EMI.

5.4.6 Interior Wiring, Conductors, and Cables

Permanent single conductors, cables and wiring shall be in ferrous raceway systems, such as RGS conduit, intermediate metal conduit (IMC), electrical metallic tubing (EMT) conduit, cable tray, or wireway, except when prohibited by NEC. Flexible metal conduit (FMC) is permitted when installed in accordance with FAA-C-1217.

Cable tray systems comprising single rail or wire construction are permitted where the installation of conventional ladder cable tray is impractical, provided the cable tray system meets the following requirements:

a. Suitable for use and classified by UL as an EGC.

b. Installed in accordance with manufacturer instructions to maintain the UL classification.

5.4.6.1 Metal-Clad Cable - Type MC

Type MC cable is permitted when installed in accordance with FAA-C-1217 and where all of the following conditions are met:

a. The MC cable shall include a steel armor of interlocking metal tape or sheath construction to form a ferrous magnetic exterior shield. MC cable with an aluminum exterior shield is prohibited.

b. Both ends of the MC cable shall be terminated using UL-listed compression fittings recommended by the OPR of this document.

c. The MC cable shall include a separate internal equipment grounding conductor or wire.

When MC cables are installed in MC cable tray, the following conditions shall be met:

a. The MC cable shall be UL-listed and marked suitable for use in metallic cable tray (hereinafter referred to as MC cable tray).

b. The MC cable tray shall be used exclusively for MC cable and type UL-listed raceways for power distribution.

c. The MC cable tray shall be separated from all other cable trays that transport non-axial communications, signal, and/or control cables or conductors by at least 12 in. The MC cable tray shall not carry more than 90 individual power branch circuits.

d. The MC cable bend radius shall be in accordance with the NEC and cable manufacturer installation instructions, but not less than 8 in.

5.5 Single Point Ground System (SPG) – Special Conditions

5.5.1 General

An SPG shall be provided when required by the electronic equipment or requested by the electronic equipment vendor. FAA facilities that do not use single-point-ground equipment are not required to install an SPG. The SPG shall be isolated from the power grounding system, the lightning protection system, MPG, or SRGG and SRGP systems, except at the main ground plate. The SPG shall be terminated at the main ground plate or to the EES, whichever is closer. The SPG shall be configured to minimize conductor lengths. Conductive loops shall be avoided by maintaining a trunk and branch arrangement as shown in Figure 20.

5.5.2 Isolation between SPG and Other SRS Systems

The minimum resistance between the SPG and the MPG, SRGG, or SRGP systems shall be 10 MΩ. The resistance shall be measured after the complete network is installed and before connection to the EES or SRS system at the main ground plate.

5.5.3 Resistance of Bonds

The maximum resistance of a bond connection from a conductor to a ground plate shall not be greater than 1 mΩ.

5.5.4 SPG - Ground Plates

Main, branch, and feeder ground plates shall be copper and at least 4 in. wide and 1/4 in. thick. The plates shall be mounted to nonconductive material of sufficient cross-section to rigidly support the plates after all conductors are connected. Bolts or other devices used to secure the plates in place shall be insulated or shall be of a nonconducting material. The plates shall be mounted in a manner that provides ready accessibility for inspection and maintenance.

See Table 4 for the single ground plate installation requirements.

5.5.5 SPG - Ground Conductors

Ground conductors shall be insulated copper conductors color-coded green with a yellow tracer.

5.5.5.1 Main SPG Conductor

Where an SPG is established directly from the EES, the SPG main conductor shall be an insulated 500 kcmil copper conductor not exceeding 50 ft in length. The main ground conductor shall be connected to the EES by an exothermic weld in accordance with paragraph 4.2.3.1.

5.5.5.2 Trunk and Branch Ground Conductors

Provide an insulated trunk ground conductor to interconnect all branch ground plates to the main ground plate as illustrated in Figure 20. Provide insulated copper branch ground conductors to interconnect feeder plates to branch ground plates. Conductor insulation shall be green with yellow tracer. Trunk and branch conductors shall be connected to ground plates by exothermic welds or UL-listed double-bolted connections in accordance with paragraph 4.2.3.4, and shall be mounted as shown on the facility drawings.

Trunk and branch conductors shall be routed using the shortest possible path.

a. <u>Conductors Shorter than 400 ft</u>. Trunk conductors shall be 4/0 AWG insulated copper conductors where the conductor length to the farthest feeder plate in the system is no more than 400 ft from the EES via the conductor runs.

b. <u>Conductors Longer than 400 ft</u>. For longer runs, select a conductor size to provide a cross-sectional area of 500 cmil per linear foot of conductor, but in no case that the conductor is smaller than 250 kcmil.

5.5.5.3 Electronic Equipment SPG Conductors

The conductor from the feeder ground plate (branch ground plate when there are no feeder ground plates in the conductor run) shall be connected to the isolated ground terminal or bus on the electronic equipment. This conductor shall be sized in accordance with Table 3.

5.5.5.4 Interconnections

Connections to the SPG shall be made on ground plates or buses. Split bolts and other connections to existing conductors are not allowed.

5.5.6 Labeling

The SPG shall be clearly labeled to preserve its identity as described in the following paragraphs.

5.5.6.1 Conductor Identification

SPG conductors shall be labeled in accordance with paragraph 4.7.3.1.6.

5.5.6.2 Ground Plate Labeling

Ground plates shall be installed according to Table 4.

5.5.7 Protection

Provide protection for conductors in the SPG subject to physical damage by use of conduit, floor trenches, routing behind permanent structural members, or other approved means. Single-point ground conductors shall be isolated from contact with any metal elements.

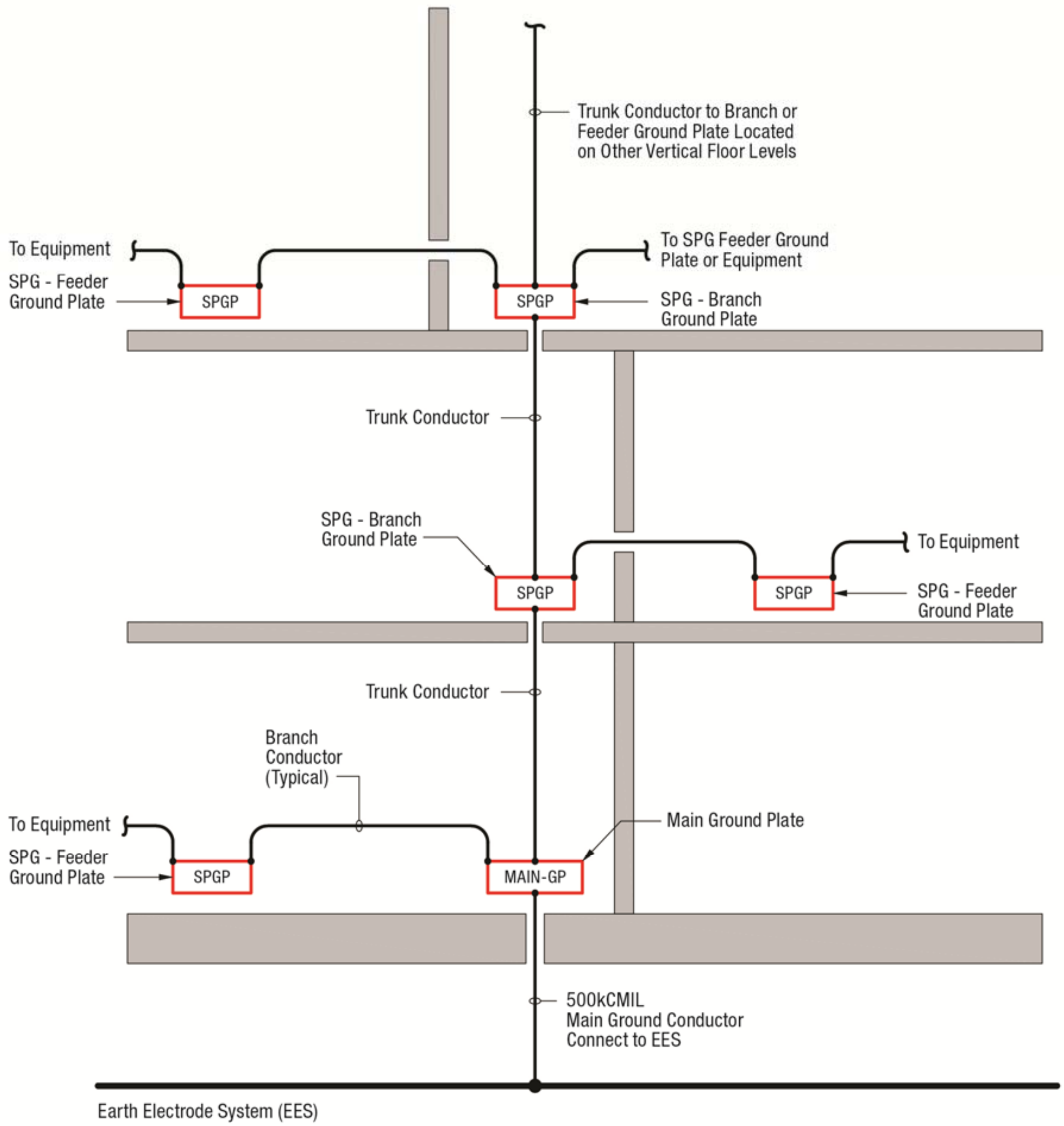


Figure 20. Single-Point Ground System Installation – Illustrative Example

5.6 NAS Electronic Equipment – Interface and Procurement Requirements

5.6.1 General

This section provides detailed performance and interface requirements for installation and procurement of NAS electronic equipment. Electronic equipment installed in NAS facilities shall comply with the requirements herein that address the following:

a. Electronic Signal Lines and Cables – Shielding

b. Signal, Control, and Data Line Entrance – Transient Protection

c. Equipment Power Entrance – Transient Protection

d. Electronic Equipment – Grounding and Bonding

e. Equipment – Signal Grounding and Bonding

f. Equipment Shielding Requirements

g. Circuit and Equipment ESD Design Requirements

5.6.2 Electronic Signal Lines and Cables - Shielding

Electronic signal lines shall be shielded twisted pairs with an insulated covering. Cables consisting of multiple twisted pairs shall have the individual shields isolated from each other. Cables shall have an overall shield with an overall insulated covering.

5.6.2.1 Electronic Signal Return Path

The electronic signal return path shall be routed with the circuit conductor. For axial circuits, the shield serves this purpose. The electronic equipment case and SRS shall not be used as a signal return conductor.

5.6.2.2 Termination of Individual Shields

Termination of individual shields shall be in accordance with paragraph 4.8.3.2.

5.6.2.3 Termination of Overall Shields

Termination of overall shields shall be in accordance with paragraph 4.8.3.3.

5.6.3 Signal, Control, and Data Line Entrance – Transient Protection

Procurement organizations are responsible for ensuring that electronic equipment, such as radars, NAVAIDS, and transmitters shall be provided with transient protection to reduce surges and transients to below the equipment transient susceptibility level. Signal, control, data line, and antenna cabling entrance transient protection shall be provided at the facility entrance point and at electronic equipment. Equipment SPDs shall be an integral part of the equipment, installed either internally or on the exterior of the equipment. Coordination of these protectors shall be addressed and completed in the system design stage and should not be delegated to field personnel during construction.

Equipment susceptibility level is defined as the transient level on the signal, control, or data lines that cause damage, degradation, or upset to electronic circuitry connected to the line. Transient protection for these lines is in addition to the facility transient protection levels specified in paragraphs 5.7.2 through 5.7.4. Procurement organizations are responsible for ensuring that testing is performed to establish voltage, current, and energy levels that will damage components, shorten operating life, or cause operational upset to the equipment. These tests shall include electrical and electronic equipment components exposed to the effects of surges or transients.

The procurement organization shall ensure that facility and electronic equipment entrance transient protection is coordinated to limit transients at the equipment to below the equipment susceptibility level. Requirements of this paragraph shall be included in the comprehensive control and test plans included in paragraph 5.9.2. The following characteristics shall be evaluated:

a. Component Damage Threshold. The component damage threshold is the transient level that renders the component nonfunctional or operationally deficient. Voltage is usually the relevant parameter for solid-state components.

b. Component Degradation Level. The component degradation level is the transient voltage or energy level that shortens the useful life of the component.

c. Operational Upset Level. The operational upset level is the transient voltage or energy level that causes an unacceptable change in operating characteristics for longer than 10 milliseconds for analog equipment or a change of logic state for digital equipment.

5.6.3.1 Lines and Cables Requiring Protection

Surge protective devices shall be placed on both ends of signal, data, antenna, and control lines and cables longer than 10 ft where connecting pieces of electronic equipment are not located and bonded to the same SRS, or where the SRS ground system is located in different rooms or on different building floor levels, as illustrated in Figure 21. Electronic equipment shall be protected as specified in paragraph 5.6.3.

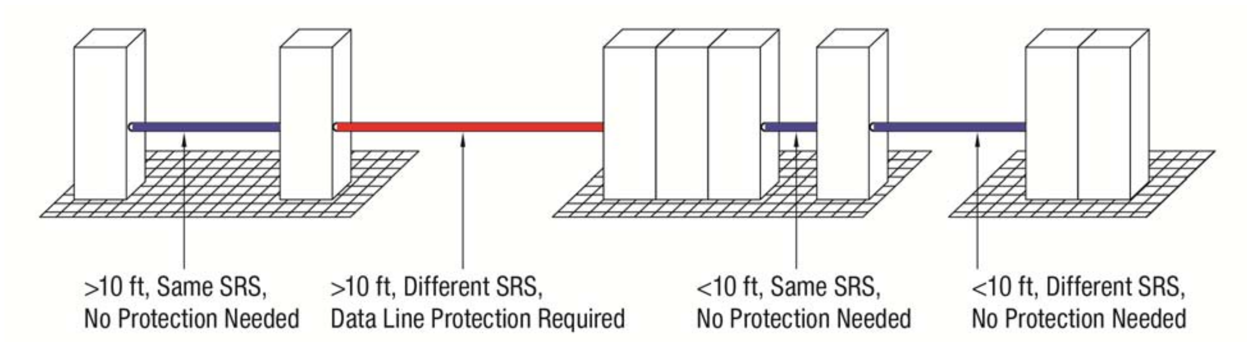


Figure 21. Lines and Cables Requiring Protection

5.6.4 Equipment Power Entrance – Transient Protection

SPDs, components, or circuits for the protection of electronic equipment power lines shall be provided by the equipment manufacturer as an integral part of electronic equipment mounted internally or on the exterior of the equipment at the cable entrance point. These devices shall be located at the ac power conductor entrance to electronic equipment housed in a shielded, compartmentalized enclosure. SPDs at equipment shall provide a clamping level less than the equipment operational upset susceptibility level as defined in paragraph 5.6.3c and shall conform to Table 8, Table 9, and Table 10.

a. Maximum Continuous Operating Voltage (MCOV). The MCOV is the maximum rms voltage an SPD can withstand while operating continuously at maximum temperature without degradation or change to any of its parameters greater than +/-10 percent. The MCOV shall be at least 10 percent above the nominal system voltage, and leakage current, as defined below, shall not be exceeded.

b. Leakage Current. The dc leakage current shall be less than 1 mA for voltages at or below the dc voltage value of 1.414 x MCOV.

c. Clamping Discharge Voltage (CDV). The CDV is the maximum voltage that appears across an SPD output terminal while conducting surge currents. To ensure performance in the linear region without impacting the device lifetime performance, the CDV values measured at 3 kA for an 8/20 µs current impulse waveform shall not change more than 10 percent over the operating life of the SPD as defined in Table 10.

d. Overshoot Voltage. Overshoot voltage is the surge voltage level that appears across the SPD terminals before the device turns on and clamps the surge to the specified voltage level. Overshoot voltage shall not exceed two times the SPD clamping voltage for more than 10 ns.

e. Self-restoring Capability. The SPD shall automatically return to its off state after surge dissipation when line voltage returns to normal.

f. Operating Lifetime. The SPD shall safely dissipate the number and amplitude of surges listed in Table 10.

g. Fusing. The SPD overcurrent protection shall not increase the clamp voltage of the SPD and shall pass the surge current levels listed in Table 10 up to the 20 kA level without opening. Fusing shall be coordinated with the power source overcurrent protection scheme.

5.6.4.1 Slope Resistance

The purpose of this parameter is to establish a system that ensures SPD device coordination for equipment protection. The slope resistance R_{slope}, as calculated by the formula below, shall comply with Table 8:

$R_{slope} = (V_{10} - V_1)/9000$

Where V_{10} is the clamping voltage measured at 10 kA for an 8/20 µs waveform and V_1 is the clamping voltage measured at 1 kA for an 8/20 µs waveform.

The values of V_{10} and V_1 shall be based on actual measured values of SPD performance testing and not calculated values.

Table 8. Electronic Equipment Power Entrance SPD - Slope Resistance (R_{slope})

Location	Slope Resistance Value
Electronic equipment power entrance	60 mΩ minimum

5.6.4.2 SPD Voltage Protection Rating - V_3

SPD voltage protection rating shall be based on actual measured values of SPD performance testing and not calculated values. Voltages to be achieved during testing at 3 kA for an 8/20 µs current impulse waveform are shown in Table 9. All voltages shall be measured at the device terminals. The 8/20 µs waveform shall not lead or lag the voltage waveform by more than 30 degrees.

Table 9. Electronic Equipment Power Entrance SPD - Voltage Protection Rating (V_3)

Location	System Voltage (V)	SPD Voltage Protection Rating (V_3 per mode)	Limit
Electronic equipment power entrance	120/208 or 120/240	550 L-N, L-G 850 L-L	Minimum
	277/480	850 L-N, L-G 1350 L-L	Minimum
	380 Delta	1350 L-L, L-G	Minimum
	480 Delta	1350 L-L, L-G	Minimum

Table 10. Electronic Equipment Power Entrance SPD – Surge Current Lifetime Rating

Surge Current Level Amplitude with an 8/20 µs Waveform (see note 1) (kA)	**Number of Surges** Lifetime
1	100
10	25
20	1

Note:
1. Each level of surge current and the number of lifetime surges required represents a single lifetime of the SPD.

5.6.4.3 Electronic Equipment dc Power Supplies – Transient Protection

Procurement organizations are responsible for ensuring that equipment power supplies that use 60 Hz power to derive dc operating voltages for solid-state electronic equipment supporting the NAS shall have transient suppression components installed for each power supply output line. The suppression components shall be bonded to the protection equipment chassis. The chassis side of the suppressor enclosure shall be bonded to the rectifier output ground connection. The suppressor should be located as close as possible to the rectifier grounding connection. Suppression components for power supply's rectifier output lines shall comply with following operating characteristics:

a. Operating Lifetime. Transient suppressors shall safely dissipate 1,000 surges at 200 A amplitude for a 1.2/50 μs current impulse waveform. Methods of testing shall be in accordance with the guidance in IEEE C62.45.

b. Limiting Voltage. Voltage shall be limited to a point 20 percent below the maximum peak inverse voltage (PIV) of the dc rectifier.

5.6.5 NAS Electronic Equipment Enclosures and Assemblies - Grounding and Bonding

Bonding connections for electronic equipment enclosures and assemblies shall be prepared and completed in accordance with the installation conditions and requirements provided herein.

5.6.5.1 Electronic Equipment Cabinets, Racks, and Cases

Cabinets, racks, and cases shall be provided with a grounding terminal or bus assembly whereby a bonding jumper or wire can be mechanically connected through an electrically conductive surface to the chassis frame. The metal enclosure of each individual unit or piece of electronic equipment shall be bonded to its cabinet, rack, or directly to the SRS or MPG system.

5.6.5.2 Equipment Enclosures - Isolated Grounding Receptacles

Isolated receptacles installed in accordance with the NEC are permitted for reduction of electrical noise. Isolated EGCs used for these receptacles shall be color-coded green with red and yellow tracers at each termination, and where passing through an enclosure without termination.

5.6.5.3 Portable Equipment (with Grounding Conductor)

Portable electrical or electronic equipment cases, enclosures, and housings shall be considered to be effectively grounded for fault protection through the EGC of the power cord, if positive continuity is provided between the case, enclosure or housing, and the receptacle ground terminal. The power cord EGC shall not be used for signal grounding.

5.6.5.4 Alternating Current Power Filters

Filter cases shall be bonded directly to the equipment case or enclosure in accordance with paragraph 5.6.5.5. Filter leakage current shall not exceed 5 mA per filter. Transient suppression devices, components, or circuits shall be installed in accordance with paragraph 4.6.3.

5.6.5.5 Electronic Equipment Enclosure Bonding

Where subassemblies and equipment are in physical contact with the equipment enclosure, they shall be bonded directly with the enclosure and mounting surfaces.

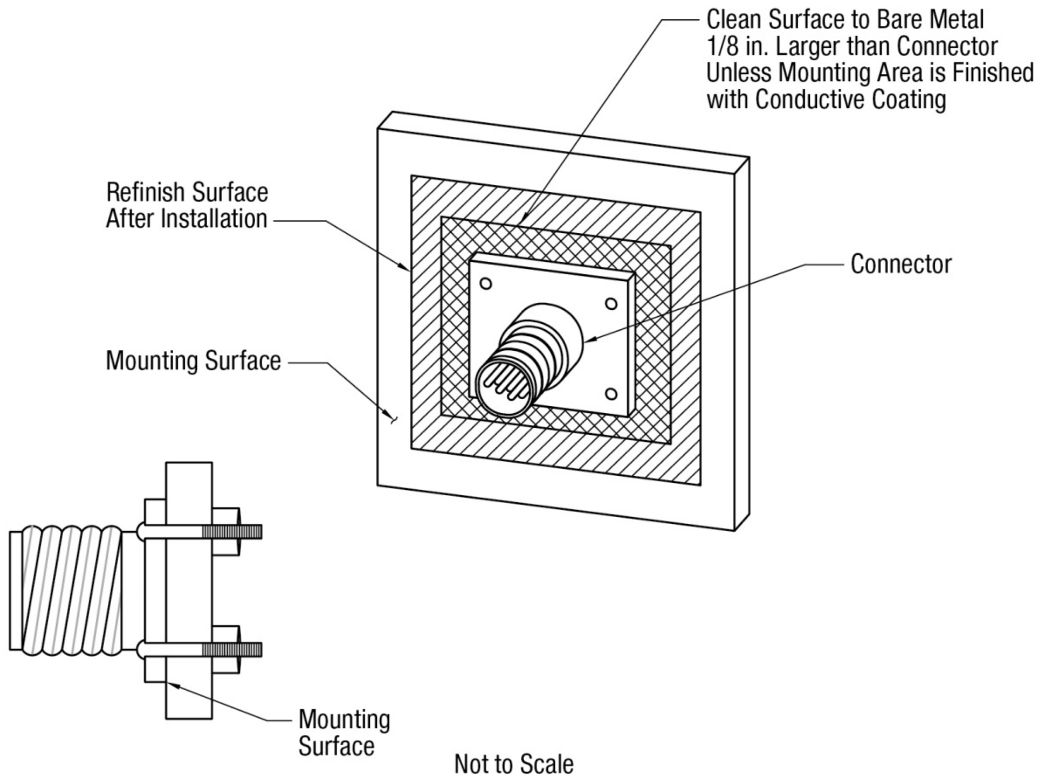
5.6.5.5.1 Enclosure Subassemblies for Equipment Mounting

Use the maximum possible contact area when bonding subassemblies to the equipment chassis. Raceway penetrations, filters, and connectors shall be bonded at the periphery to the subassembly enclosure to maintain shield effectiveness. Enclosure covers and mounting trim shall be securely fastened to the enclosure. COTS equipment is considered a sealed unit and does not require additional internal bonding for the purposes of this requirement.

5.6.5.5.2 Electronic Equipment
The equipment chassis components shall be bonded together and directly to the rack, frame, or cabinet to which they are mounted. Clean flange surfaces and the bonding contact surface in accordance with paragraph 4.2.4.1. Fasteners shall maintain sufficient pressure to ensure surface contact to meet the bond resistance requirements in paragraph 4.2.1.1. Captive nuts, sheet metal screws, and tapping screws shall not be used for fasteners. If equipment operation is necessary when partially or completely withdrawn from its mounted position, the bond shall be maintained by an effective area of direct metal-to-metal contact or by the use of a flexible bonding strap. Mechanical designs shall employ direct bonding, without bonding jumpers, whenever possible.

Exception. *Self-drilling (tapping) metal screws are permitted to make a physical connection between metal back panels within equipment cabinet/enclosures for conditions where equipment access is not available to the opposite side of the bond connection.*

5.6.5.5.3 Connector Mounting
Connectors shall be mounted so that electrical contact is maintained between the connector body and the metal mounting panel. The connector flange shall be fastened to equipment enclosure to ensure direct contact between components for effective bonding. The connector flange surface and the enclosure contact area shall be cleaned in accordance with paragraph 4.2.4.1. Nonconductive material shall be removed from the contact area as illustrated on Figure 22. After mounting each connector, the completed bond shall be sealed and finished for corrosion protection in accordance with paragraph 4.2.4.3.



Notes:

1. The connection detail depicts an illustrative example and is exaggerated for clarity.

Figure 22. Bonding of Connectors to Mounting Surface

5.6.5.5.4 Shield Terminations

Cable shields shall be terminated in accordance with paragraphs 4.8.3.2 and 4.8.3.3. Axial cable shields shall be fastened to the cable connector shell with a compression fitting. A soldered connection is permitted to improve conductivity of the shielding joints in accordance with paragraph 4.2.3f. The cable shall withstand the anticipated use without degradation in shielding efficiency performance. Axial cable connectors shall be corrosion resistant in accordance with FAA-G-2100. Low frequency shields shall be soldered in place or, if solderless terminals are used, the compressed fitting shall afford maximum contact between the shield and the terminal sleeve. The cable shield casing shall be exposed less than 1 in. from the internal conductors of the cable as illustrated in Figure 13.

5.6.5.5.5 RF Gaskets

Conductive gaskets shall be corrosion resistant, electrically conductive to meet the resistance requirements of paragraph 4.2.1.1, and resilient to ensure the shielding effectiveness of the bond. Surfaces in contact with the gasket shall be smooth and free of insulating films, corrosion, moisture, and paint. The gasket shall be firmly affixed to the bonding surface by conductive cement and screw fasteners, a milled slot or other means that do not interfere with the effectiveness of the gasket. These methods shall prevent lateral movement or dislodging of the gasket when the bond is disassembled. Gaskets shall be a minimum of 1/8-in. wide. The gasket and the contact surfaces shall be protected from corrosion.

5.6.6 NAS Electronic Equipment – Equipment Grounding and Bonding

5.6.6.1 Equipment Input and Output Electronic Signals

If a common signal reference is used, low-frequency analog input and output signals shall be balanced with respect to the signal reference. Maintain complete isolation between the SPG and the MPG, SRGG or SRGP system, except at the main ground plate or EES.

5.6.6.2 Multipoint Grounding of Electronic Equipment

Where permitted by circuit design requirements, internal ground references shall be bonded directly to the chassis and the equipment case. Where mounted in a rack, cabinet, or enclosure, the electronic equipment case shall be bonded to the racks, cabinet, or enclosure in accordance with paragraph 5.6.5.1. The dc resistance between any two points within a chassis or electronic equipment cabinet serving as ground shall be less than 25 mΩ total and not more than 2.5 mΩ per joint. Shields shall be provided where required for personnel protection and EMI reduction.

5.6.6.2.1 Prevention of Resonance in Bonding Straps

Due to resonance from a single bonding strap, two widely spaced straps of unequal length shall be used to connect equipment to the multipoint grounding bus in the equipment cabinet. Bonding connections shall be as short as possible and sized in accordance with Table 3.

5.6.6.3 Single-Point Grounding of Electronic Equipment

If electronic equipment performance necessitates an isolated SPG system for proper operation, then equipment and installation shall comply with the following:

a. <u>SPG System</u>. The SPG or plane shall be isolated from the electronic equipment case. If a metal chassis is used as the SPG, the chassis shall be floated relative to the case. The SPG system shall be designed such that electronic equipment SPG may be interfaced with other electronic equipment without compromising the system. Provide filtering if this SPG is required to be isolated from high frequencies.

b. <u>SPG Conductor and Plate System</u>. The system shall not form a conductive ground loop and it should be set up as a signal drain.

5.6.6.3.1 Single-Point Isolation of Input and Output Signal Requirements

The “high” and “low” sides of input and output signals shall be isolated from the electronic equipment case and balanced with respect to the signal reference. Operating and adjusting controls, readouts, indicating devices, protective devices, monitoring jacks, and signal connectors shall be designed to isolate both the high and low side of the signal from the case.

5.6.6.3.2 Single-Point Isolation of Case Requirements

The isolation between the SPG terminals and the case shall be 10 MΩ or greater with external power, signal, and control lines disconnected from the electronic equipment.

5.6.6.3.3 Equipment Power Input Isolation Requirements
The isolation between the SPG terminal and each power conductor (including ac neutral) shall be 10 MΩ or greater with the equipment power switch in the "on" position and the equipment disconnected from its power source.

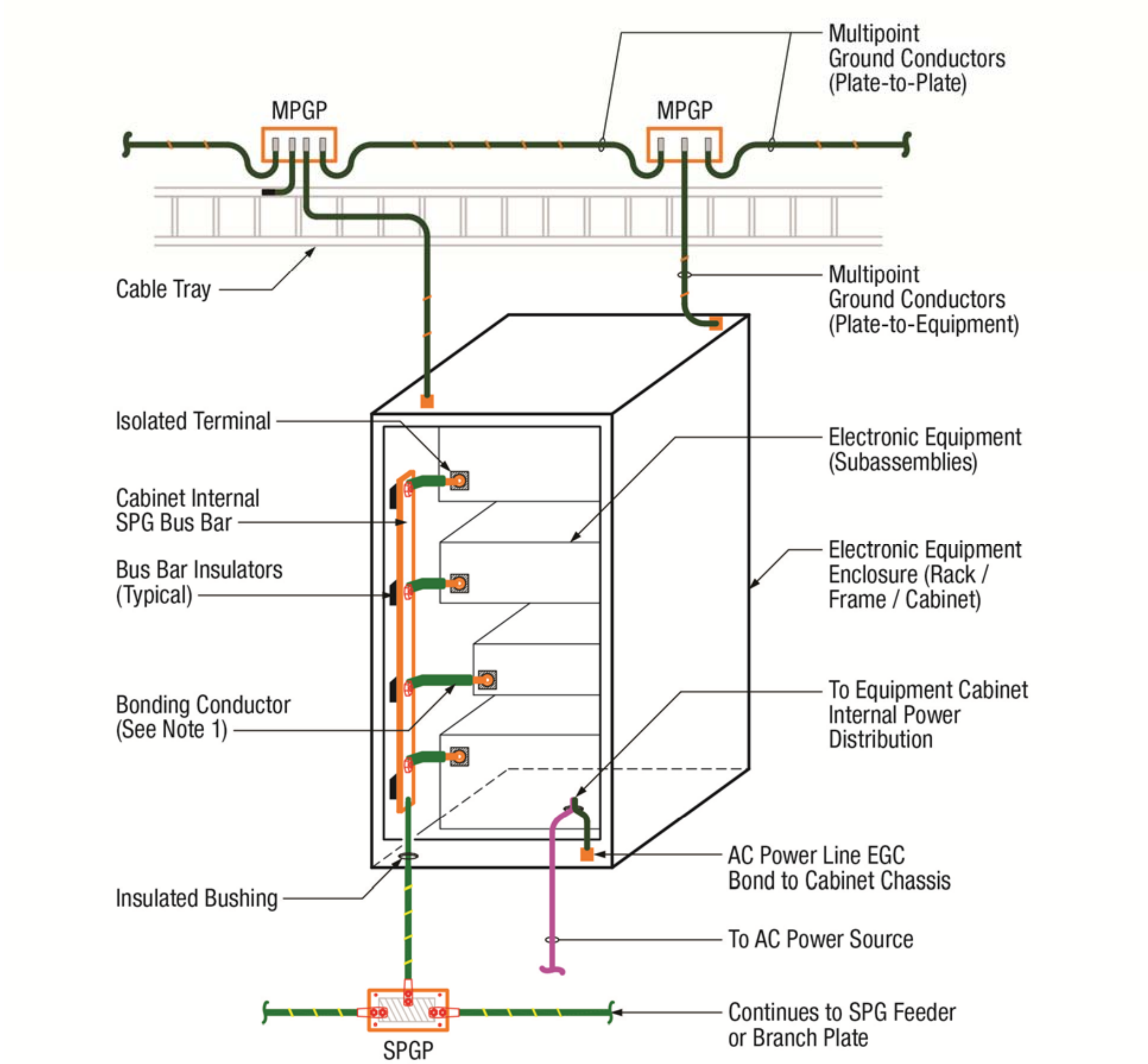
5.6.6.3.4 Equipment Single-Point Ground Terminals
An insulated SPG terminal shall be provided on each electronic equipment case where an isolated signal reference is required. The SPG reference for the internal circuits shall be connected to the SPG terminal. This terminal shall be used to terminate cable shields as appropriate, and to connect the isolated signal ground of the electronic equipment to the SPG in the facility. A connector pin, screw, terminal strip, insulated stud, jack or feed-through, or an insulated wire are acceptable terminations if each terminal is clearly marked, labeled, or coded in a manner that does not interfere with its function. These marks, codes, or labels shall be permanently affixed and use green identification with yellow stripes. Wire insulation shall be green with a yellow tracer.

5.6.6.3.5 Connection of Electronic Equipment to the SPG
Each equipment SPG terminal shall be connected to the facility SPG in accordance with the following:

a. Individually Mounted Equipment. Individual units or pieces of electronic equipment that should not be mounted with other electronic equipment due to their location or function shall have an insulated copper conductor bonded from SPG terminal as specified in paragraph 5.6.6.3.4 to the nearest SPG system. This conductor shall be sized in accordance with Table 3.

b. SPG Bus Bar. If two or more units or pieces of electronic equipment are mounted together in a rack or cabinet, then a single-point ground bus bar shall be installed as shown in Figure 23. The bus bar shall be copper and shall provide a minimum cross-sectional area of 125,000 cmils, e.g., a 1x1/8-in. bus bar. The bus bar shall be drilled and tapped for No. 10 screws, and the holes shall be located as required by the relative location of the isolated SPG terminals on the electronic equipment. The bus bar shall be mounted on insulating supports that provide at least 10 MΩ resistance between the bus bar and the rack or cabinet.

c. Interconnecting SPG Terminals to SPG Bus Bar. Each electronic equipment isolated SPG terminal shall be interconnected to the SPG bus bar by means of a solid conductor of sufficient cross-sectional area to provide a maximum resistance of 5 mΩ, or a flexible tinned copper bond jumper sized in accordance with Table 3. The bond jumper shall be insulated or mounted in such a manner to maintain the required degree of isolation between the reference conductor and the enclosure. The bond jumper shall be connected to the equipment SPG bus bar at a point nearest the equipment SPG terminal in order to minimize the conductor length. An insulated copper conductor shall be installed from the equipment SPG bus bar to the nearest SPG grounding system as illustrated in Figure 23.



Note:

1. The conductor wire size for bonding conductors from electronic equipment to internal cabinet SPG bus bar shall be based on Table 3.

Figure 23. Single Point Ground Bus Bar Installation in Rack or Cabinet

5.6.7 Equipment Shielding Requirements

5.6.7.1 Control of Apertures

Unnecessary apertures shall be avoided. Only those shield openings required to achieve proper functioning and operation of the equipment may be provided. Controls, switches, and fuse holders shall be mounted such that metal-to-metal contact is maintained between the cover housing of the devices and the case. Metal control shafts shall be grounded in accordance with paragraph 5.6.7.2. Close-fitting metal sleeves peripherally bonded to the case shall be provided only where nonconductive control shafts are necessary. The length of the sleeve shall be no less than four times its diameter. Lights shall be filtered or shielded as needed to maintain the required degree of shielding effectiveness. Openings provided for enclosure ventilation and moisture drainage shall be configured to maintain the effectiveness of the overall enclosure shielding.

5.6.7.2 Metal Control Shafts

Metal control shafts shall be grounded to equipment cases through a low impedance path provided by close-fitting conductive gaskets, metal finger stock, or grounding nuts.

5.6.7.3 Shielded Compartments

Shields shall be bonded to the chassis for fault protection in accordance with section 4.2.

5.6.7.4 Gaskets for Shielding Systems

Conductive gaskets conforming to paragraph 5.6.5.5.5 may be provided at joints, seams, access covers, removable partitions, and other shield discontinuities to the extent necessary to provide interference-free operation of the equipment under normal use and environmental conditions. Finger stock used on doors, covers, or other closures subject to frequent openings shall be installed in a manner that permits routine cleaning and maintenance.

5.6.7.5 Filter Integration

Filters on power, control, and signal lines shall be installed in a manner that maintains the integrity of the shield. Alternating current power filters shall be shielded completely with the filter case grounded in accordance with paragraph 5.6.5.4. Filters for control and signal lines shall be placed as close as possible to the point of penetration of the case to avoid long, unprotected paths inside the equipment.

5.6.8 NAS Electronic Equipment - Electrostatic Discharge Protection

ESD protection shall be provided in accordance with section 5.8.

a. Equipment Circuit Design and Layout. The design, layout, and packaging of assemblies, circuits, and components integrated into electrical and electronic equipment shall incorporate methods and techniques to reduce susceptibility to ESD.

b. Component Protection. External protection shall be provided for integrated circuits, discrete components, and other parts not having internal ESD protection that are inherently susceptible to ESD. Protective components shall be installed as close as possible to the ESD susceptible item.

c. ESD Withstand Requirements. In the installed and operational configuration equipment such as cabinets, enclosures, racks, controls, meters, displays, test points, and interfaces shall withstand a static discharge of 15,000 V in accordance with ANSI/ESDA/JEDECD JS-001, Standard for ESD Sensitivity Testing – Human Body Model (HBM). To successfully pass ESD testing requirements, the tested equipment shall not incur any operational upset, component, or assembly damage.

5.6.9 Secure Facilities

In areas of facilities required to maintain communications security, equipment and power systems shall be grounded in accordance with NACSIM-5203 and MIL-HDBK-232A.

5.6.10 High RF Field Bonding Requirements

FAA facilities that are located in proximity to other facilities that generate high RF levels need additional shielding to protect personnel and sensitive equipment from these external RF sources. When a determination is made that the signal level is sufficient to cause concern, incorporate the following requirements:

Metal building components and attachments such as walls, roofs, floors, door and window frames, gratings and other metallic architectural features shall be bonded directly to structural steel or to reinforcing bar if structural steel is not present. Where direct bonding is not possible, indirect bonds with copper conductor shall be used. Removable or adjustable parts and objects shall be grounded with an appropriate type bond strap. Metal building components with a maximum dimension of 3 ft or less are exempt from the requirements of this paragraph.

5.7 Surge Protective Device (SPD) – Equipment Specification Requirements

5.7.1 General

This section provides SPD performance requirements.

5.7.2 Surge Protective Device (SPD) for Power Distribution Equipment Protection

The SPD installation shall comply with the following:

a. Application Listing. The SPD shall be listed in accordance with the latest UL 1449 Standard for SPDs.

b. Integral Unit Mounted Assemblies. Panelboards and switchgear equipment with integral unit mounted SPD enclosures are permitted if the SPD and panelboard or switchgear integrated components are UL listed and recognized as an assembly.

c. Enclosure Rating. The SPD components shall be housed in a single steel enclosure, and classified by NEMA as type-12 for indoor use, or type-4 for indoor or outdoor use.

d. Enclosure Door Hardware. The enclosure door shall be hinged and electrically bonded with a bonding jumper connected to the enclosure. The internal components of the SPD, such as fusing, indicator lights, wiring, and protection elements, shall be accessible for inspection and replacement. The manufacturer's installation and maintenance instructions shall be provided with each SPD unit.

e. SPD Accessories. Indicator lamps shall be provided for each power phase on the SPD enclosure cover. The lamps shall indicate visually the normal condition when power is applied to the SPD with the component fusing intact. Lamps shall be provided at a minimum service life of 50,000 hours, otherwise two lamps per phase shall be provided.

f. Potting Material. The SPD enclosure shall be sealed at the power entry points with potting material in accordance with paragraph 4.6.2.3. The use of potting material within SPD components is prohibited, such that all SPD components are accessible at all times for visual inspection, evaluation, maintenance, or replacement by qualified FAA personnel.

g. Conductor Terminations. Provide heavy-duty screw terminal studs or lugs for input and output conductor connections. The SPD phase and neutral terminals, when not connected, shall be electrically isolated from the enclosure by a minimum of 10 MΩ resistance measured at 100 Vdc.

5.7.2.1 SPD - Operational Requirements

The SPD equipment performance shall conform to Table 11, Table 12, and Table 13, and the following parameters:

a. Maximum Continuous Operating Voltage. The MCOV is the maximum rms voltage an SPD can withstand while operating continuously at maximum temperature without degradation or change to any of its parameters greater than +/-10 percent. The MCOV shall be at least 10 percent above the nominal system voltage. Leakage current, as defined below, shall not be exceeded.

b. Leakage Current. The dc leakage current shall be less than 1 mA for voltages at or below the dc voltage value of 1.414 x MCOV.

c. Clamping Discharge Voltage. The CDV is the maximum voltage that appears across an SPD output terminal while conducting surge currents. To ensure performance in the linear region without impacting the device's lifetime performance, the CDV values measured at 3 kA for an 8/20 μs current impulse waveform shall not change more than 10 percent over the operating life of the SPD as defined in Table 11.

d. Overshoot Voltage. Overshoot voltage is the surge voltage level that appears across the SPD terminals before the device turns on and clamps the surge to the specified voltage level. Overshoot voltage shall not exceed two times the SPD clamping voltage for more than 10 ns.

e. Self-restoring Capability. The SPD shall automatically return to its off state after surge dissipation when line voltage returns to normal.

f. Operating Lifetime. The SPD shall safely dissipate the number and amplitude of surges listed in Table 11.

g. In-line Inductors. In-line inductance is not permitted, except from the inductance normally created by the power connection conductors.

h. Overcurrent Protection. Fuses or circuit breakers that are part of an SPD installation shall be able to pass the surge currents specified in Table 11 without opening.

i. Short Circuit Current Rating. The SPD short circuit current rating shall be greater than the power distribution system available short circuit current where the equipment is applied in the power distribution system.

5.7.2.1.1 SPD Equipment Performance Data - Surge Current Levels

Table 11 defines the line-to-ground, line-to-neutral, neutral-to-ground, and line-to-line surge current values, and number of surge occurrences for ac power distribution SPD equipment operating below 600 V. In this table, the 8/20 μs waveform defines a transient reaching peak value in 8 µs and decaying to 50 percent of peak value 20 µs after inception. These devices shall be able to tolerate surges of shorter duration without malfunction.

The following performance change measurements define SPD device failure modes. For the listed parameters, the clamping voltages for each device and assembly are measured at 1 kA and 10 kA for an 8/20 µs current impulse waveform.

a. Change in Clamping Voltage. Any change greater than 10 percent in the 8/20 µs clamping voltage at 3 kA during service or when the pre-life service test and post-life or in-service test results are compared is a device failure. The pre-life test value shall be taken as the 100 percent value.

b. Change in rms Voltage. Any change greater than 10 percent in the rms voltage required to drive 1 mA of rms current through the device when the pre-life service test and post-life or in-service test results are compared is a device failure. The pre-life test value will be taken as the 100 percent value.

c. Change in dc Voltage. Any change greater than 10 percent in the dc voltage required to drive 1 mA dc through the device when the pre-life service test and the post-life or in-service test results are compared is a device failure. The pre-life test value will be taken as the 100 percent value.

Table 11. Power Distribution Equipment SPD – Surge Current Lifetime Rating

Surge Current Level Amplitude with an 8/20 µs Waveform, See Note 1 (kA)	**Number of Surges** Lifetime for Any Facility Entrance SPD	**Number of Surges** Lifetime for Feeder and Branch Panelboard SPDs
10	1500	1000
20	700	500
30	375	250
40	50	25
50	8	1
60	6	N/A
70	4	N/A
100	2	N/A
200	1	N/A

Table Note:
1. Each level of surge current and the number of lifetime surges required represents a single lifetime of the SPD.

5.7.2.1.2 SPD - Slope Resistance

The purpose of this parameter is to establish a system that ensures SPD device coordination for equipment protection. The slope resistance R_{slope}, as calculated by the formula below shall comply with Table 12:

$R_{slope} = (V_{10} - V_1)/9000$

Where V_{10} is the clamping voltage measured at 10 kA for an 8/20 µs waveform and V_1 is the clamping voltage measured at 1 kA for an 8/20 µs waveform.

The values of V_{10} and V_1 shall be based on actual measured values of SPD performance testing and not calculated values.

Table 12. Power Distribution Equipment SPD - Slope Resistance (R_{slope})

Location	Slope Resistance Value
Any Facility Entrance	8 mΩ Maximum
Feeder and Branch Panelboards	30 mΩ +/- 15 mΩ

5.7.2.1.3 SPD - Voltage Protection Rating V_3

SPD voltage protection rating shall be based on actual measured values of SPD performance testing and not calculated values. Voltages to be achieved during testing at 3 kA for an 8/20 µs current impulse waveform are shown in Table 13. All voltages shall be measured at the device terminals. The 8/20 µs waveform shall not lead or lag the voltage waveform by more than 30 degrees.

Table 13. Power Distribution SPD Voltage (V_3) Protection Rating

Location	System Voltage (V)	SPD Voltage Protection Rating (V_3 per mode)	Limit
Facility Entrances	120/208 120/240	400 L-N, L-G 700 L-L	Maximum
	277/480	700 L-L, L-G	Maximum
	380 Delta	1200 L-L,L-G	Maximum
	480 Delta	1200 L-L, L-G	Maximum
Feeder and Branch Panelboards	120/208 120/240	475 L-N, L-G 775 L-L	+/- 45 V
	277/480	775 L-N, L-G 1275 L-L	+/- 45 V
	380 Delta	1275 L-L, L-G	+/- 45 V
	480 Delta	1275 L-L, L-G	+/- 45 V

5.7.3 SPDs for NAS Electronic Equipment – Design and Procurement Requirements

Provide surge protection for NAS electronic equipment in accordance with paragraph 5.6.3.

5.7.4 SPD - Design Specification for Axial Cable Protection

The design analysis for axial-type cable transient protection shall address the critical RFs and cable insertion losses. Axial cable protection shall comply with the following:

a. Testing. Performance testing shall be conducted to ensure that suppression components do not degrade signals or cause disruption to the electronic equipment.

b. RF Signal Testing Criteria. The analyses shall address cable impedance, insertion loss, phase distortion, and system voltage standing wave ratio.

c. Transient Protection for Electronic Equipment. SPD protection for coaxial, tri-axial, and twin-axial cables shall be provided at the facility entrance point and at the electronic equipment. The transient suppression shall be provided for each axial conductor and for shields that are not bonded directly to the electronic equipment chassis.

5.8 Electrostatic Discharge (ESD) Protection – Interface and Specification Requirements

5.8.1 General

This section provides performance and interface requirements for installation of ESD protective systems. ESD controlled areas shall be provided for operations, storage, repair, and maintenance spaces used for electrical and electronic equipment or subassemblies that are subject to damage from static electricity or ESD. NAS electrical and electronic equipment, subassemblies, and components subject to damage from exposure to electrostatic fields or ESD shall be protected as indicated herein. Approval of any exception to the guidance herein shall be by the OPR.

The requirements of this section are designed to reduce frequency and minimize effects of ESD events. Electronic circuitry that contains miniaturized or solid-state components shall be considered ESD susceptible.

5.8.2 Electrostatic Discharge (ESD) Sensitivity Classification

Classification of items as ESD sensitive shall be in accordance with the HBM testing procedures and requirements of ANSI/ESDA/JEDECD JS-001. Electronic parts, components, and assemblies shall be classified as either sensitive or supersensitive. Items that fail from ESD at 1,000 to 16,000 V shall be classified as ESD sensitive. Items that fail below 1,000 V shall be classified as supersensitive. Devices with a sensitivity of less than +/- 200 V require additional ESD protection measures beyond those specified in this standard. ESD susceptible items shall not be exposed to an electrostatic field greater than 100 V/m, nor located within 24 in. from known static generators or nonessential insulated materials.

5.8.3 Classification of Materials

Most materials and products that are used to control and prevent ESD are classified by their resistive properties as conductive or static dissipative. Antistatic materials are classified by their ability to avoid generating static electricity from triboelectric charging.

Materials used for construction of ESD protected areas (with the exception of antistatic materials) shall meet the resistive properties specified for type and use of the material.

5.8.3.1 Static Conductive Materials

Those materials with a surface resistivity less than 1.0×10^5 ohms per square when tested per ANSI/ESD STM11.11 shall be considered conductive. Conductive ESD control materials shall not be used for ESD control work surfaces, tabletop mats, floor mats, flooring, or carpeting where the risk of personnel contact with energized electrical or electronic equipment exists. Conductive ESD control materials shall not be used in any other application where their use could result in EMI or radio frequency interference (RFI) that would be created by rapid, high-voltage ESD spark discharges.

5.8.3.2 Electrostatic Shielding Materials

Electrostatic shielding materials are a subset of conductive materials with a surface resistance equal to or less than 1.0×10^3 ohms when tested per ANSI/ESD STM11.11. Electrostatic shielding materials are permitted as barriers for protection of ESD sensitive items from electrostatic fields.

5.8.3.3 Electromagnetic Shielding Materials
Electromagnetic shielding materials with highly conductive surfaces less than 10 ohms, or composite materials that absorb and reflect electromagnetic radiation over a broad range of frequencies, are permitted for protection of ESD sensitive items from electromagnetic fields.

5.8.3.4 Static Dissipative Materials
Materials with a surface resistivity greater than 1.0 x 10^5 ohms per square but less than or equal to 1.0 x 10^{12} ohms per square when tested per ANSI/ESD STM11.11 are classified as static dissipative materials. Static dissipative materials with a surface resistance less than or equal to 1.0 x 10^9 ohms shall provide controlled bleed-off of accumulated static charges in ESD controlled areas. Static dissipative materials with a surface resistance of greater than 1.0 x 10^9 ohms are not permitted for applications where controlled bleed-off of accumulated static charges is required.

5.8.3.5 Antistatic Materials
Materials that inhibit or have a low propensity to generate static electricity from triboelectric charging shall be considered antistatic. Antistatic ESD control items and materials used for construction of ESD controlled areas shall not tribocharge to greater than +/-200 V when being used for their intended application. Antistatic materials with a surface resistance greater than 1 x 10^9 ohms shall not be used for ESD protective work at surfaces, tabletop mats, floor mats, flooring, and carpeting when charge dissipation is the primary consideration. If the surface resistance (R_{tt}) of an antistatic material is greater than 10^{12} ohms, it shall be considered too resistive for use in ESD controlled areas. Use of antistatic items and materials that use hygroscopic surfactants that depend on ambient humidity to promote absorption of water is discouraged. Only antistatic materials that are intrinsically antistatic and retain their antistatic properties shall be used in ESD controlled areas.

5.8.3.6 Static-Generative Materials, Nonconductors, and Insulators
Materials having a surface resistance greater than 1.0 x 10^{12} ohms (ANSI/ESD STM11.11) shall be considered to be insulators and a potential source of triboelectric charging. These materials include common plastics, Plexiglas, Styrofoam, Teflon, nylon, rubber, untreated polyethylene, and polyurethane. Use of these materials shall be minimized where ESD sensitive items are located.

5.8.4 Hard and Soft Grounds

5.8.4.1 Hard Grounds
Any item, material, or product that is a part of the ESD control system that is intentionally or unintentionally connected to an ESD ground, or connected directly to any SRS in the area served, but not to an SPG system, shall be considered to be hard grounded. Unless specified otherwise or approved by the OPR, all items that comprise the ESD control system shall be hard grounded, such as worksurfaces, cabinets, flooring, carpeting, and test equipment.

5.8.4.2 Soft Grounds

A soft ground is an intentional connection to ground through a series current limiting resistor. Soft grounding shall only be used for personnel grounding skin contact devices, such as wrist straps, leg or ankle straps, conductive shoes, and heel or toe grounders. The nominal resistance of the resistor used for soft grounding of personnel shall be greater than 1.0 x 10^6 ohms unless otherwise approved by the OPR. All other elements of the ESD control system shall be hard grounded.

5.8.5 Protection of Electrostatic Discharge (ESD) Susceptible and Sensitive Items

5.8.5.1 Static Protected Zone

A static protected zone shall be a volume or area where there is no direct contact between unprotected ESD sensitive items and electrostatic potentials greater than +/-200 V, electrostatic fields greater than 100 V/m, or radiated EMI and RFI produced by rapid high-voltage ESD spark discharges. Static protected zones shall be incorporated into the construction of ESD special protection areas, ESD protected storage areas, and ESD protected workstations.

5.8.5.2 ESD Special Protection Areas

Special protection areas shall be designated areas that require the following ESD control measures:

a. Minimize triboelectric charging.

b. Control bleed-off and dissipation of accumulated static charges.

c. Neutralize charges.

d. Minimize the effects of e-fields, h-fields, and EMI/RFI from ESD spark discharges.

Areas within a facility that shall be designated as ESD special protection areas are:

a. Air Traffic Operations Areas. These include tower cab, TRACON, ARTCC control rooms, and automated flight service station (AFSS) areas.

b. Electronic Equipment Rooms.

c. Storage Areas. Areas to store ESD-susceptible components such as subassemblies and circuit cards.

d. Computer/LAN Interface Areas. Areas that contain personal computers and LANs that are connected to or interface directly with NAS electronic equipment.

e. Other Locations. Locations where jacks, plug-in connectors, or interfaces of ESD sensitive electronic equipment are exposed and vulnerable to ESD damage by direct human contact.

5.8.6 ESD Controls Required for ESD Special Protection Areas

The following ESD control measures shall be implemented in areas designated as ESD special protection areas.

5.8.6.1 ESD Groundable Point (GP)

Each ESD control material, surface, or item used in an ESD controlled area shall have a designated GP to provide ease of connection to the nearest SRS.

5.8.6.2 Grounded Static Dissipative Surfaces

Work surfaces which include work surface laminates, paints and sealers, writing surfaces, tabletops, consoles, ESD protected workbenches, and tabletop mats shall be static dissipative and connected to an SRS in the area served, but not to an SPG system. The point-to-point resistance and surface-to-ground resistance of static dissipative work surfaces shall be greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ANSI/ESD S4.1).

5.8.6.3 Limiting the Use of Non-ESD Control Materials

Materials that will tribocharge, i.e., generate electrostatic potentials by contact and separation with themselves or other materials, shall not be used for construction in ESD special protection areas. Insulative materials and any other non-essential triboelectric charge generators that generate potentials in excess of +/-200 V are not permitted within 24 in. of ESD special protection areas.

5.8.6.4 Static Dissipative Chairs

Chairs provided for ESD special protection areas shall incorporate a continuous path between chair elements, such as the cushion and arm rests, to the ground points in the range of greater than 1.0 x 10^5 ohms to less than 1.0 x 10^9 ohms. The ground points for ESD chairs shall be static dissipative or conductive casters that provide electrical continuity from all elements of the chair to ESD control carpeting, tile, or floor mats. These ground points shall be properly bonded to any SRS in the area, but not to an SPG system. ESD control chairs shall be tested and meet the requirements of ANSI/ESD STM12.1.

5.8.6.5 Static Dissipative ESD Control Floor Coverings

Static dissipative ESD control floor coverings shall include static dissipative tile, carpeting, static limiting floor finishes, and floor mats. Floor coverings in ESD special protection areas shall have a point-to-point resistance and surface-to-ground resistance of greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ANSI/ESD STM 7.1). These floor coverings shall be bonded to any SRS in the area served in accordance with paragraphs 5.8.6.1 and 5.8.9, but not an SPG system.

In circumstances involving extremely static sensitive equipment, a static conductive floor covering with a lower resistance limit of 2.5 x 10^4 ohms (UL 779) shall be provided when it is part of a system designed for ESD control for the equipment. The system design shall meet all requirements of this standard to produce an electrically safe working environment, and be approved by the OPR.

5.8.6.6 Relative Humidity Control

Relative humidity in ESD special protection areas shall be maintained within the range of 40 to 60 percent.

5.8.7 ESD Signs, Labels, Cautions, and Warnings for ESD Protection Areas

ESD warning signs shall be posted in ESD special protection areas and other ESD controlled areas. Sign labels shall be marked with an ESD sensitive electronic device warning symbol and other warning and caution labeling information appropriate for personnel safety. ESD warning signs shall be colored yellow with black marking labels and lettering. ESD signs for exterior cabinets housing ESD sensitive electronic equipment shall be visible from at least 3 ft. The sign and labeling style and format shall be consistent, and comply with ANSI/ESD S8.1.

5.8.8 Electrostatic Discharge (ESD) Protective Storage Areas

5.8.8.1 Shelves, Bins, and Drawers

Shelves, bins, and drawers shall be static dissipative and electrically continuous with the support structure for the storage shelves, bins, or containers.

5.8.8.2 Grounding

The storage container metal support structure shall have a GP connected to the nearest SRS in the area, but not to an SPG system. The resistance from the ground point of storage containers, shelving, cabinets, and bins used to store ESD sensitive items to the nearest SRS shall be less than 1 ohm.

5.8.8.3 Personnel Grounding

Wrist straps shall be equipped with 1 megohm or greater series resistance to protect personnel. Standard 0.157-in. banana jacks for personnel grounding wrist straps shall be connected to the ESD ground or directly to any SRS in the area served, but not to an SPG system. The resistance between the banana jack and the GP, and the GP to the nearest SRS, but not to an SRS system, shall be less than 1 ohm.

5.8.8.4 Materials Prohibited in ESD Protective Storage Areas

Static generative insulators materials are prohibited for construction in areas where ESD sensitive items will be stored. Materials that can generate potentials greater than +/-200 V shall be located a minimum of 24 in. from ESD protected storage areas.

5.8.8.5 Resistance to ESD Ground for Shelves, Drawers, and Bins

Surfaces and drawers of storage media shall be composed of static dissipative materials and shall conform to the resistance testing requirements for worksurfaces (ESD S4.1). The surface-to-surface resistance (R_{tt}) and surface-to-ground resistance (R_{tg}) from the shelves, bins, and drawers of storage containers used to store unprotected ESD sensitive items shall be greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ESD ADV53.1).

5.8.8.6 Identification of ESD Protective Storage Areas

Boundaries of ESD protective storage areas shall be clearly identified. Boundaries of ESD protective storage areas shall extend a minimum of 24 in. beyond the area where ESD sensitive items are located and marked with yellow tape. Highly visible ESD warning signs that are colored yellow with black markings and lettering shall be posted at entrances to these areas. Signs shall include an ESD sensitive electronic device warning symbol and other warning and caution labeling information for personnel safety.

5.8.9 Electrostatic Discharge (ESD) Control Flooring and Floor Coverings

ESD control floors and floor coverings shall have a point-to-point resistance and a surface-to-ground resistance of greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ANSI/ESD STM7.1). ESD control flooring, floor coverings, and floor tile laminates include materials such as vinyl tile, vinyl sheet, carpet, carpet tile, and carpet tile with positioning buttons, but not the applied coatings on the material.

ESD control floors and floor coverings shall be installed, grounded, and initially tested by trained installers in accordance with the manufacturer's recommendations. A representative 10-ft-square section of the flooring system shall be tested and approved by the FAA personnel prior to installation of the full flooring system.

ESD control floors and floor coverings shall be bonded to the nearest SRS in the area served, but not to an SPG system, at a minimum of four locations. The installation methods and testing shall be in accordance with the manufacturer's installation recommendations.

5.8.9.1 Surface Resistance (R_{tt})

Surface resistance R_{tt} of ESD control floors, carpets, or floor mats shall be greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ANSI/ESD STM7.1). The system surface resistance shall be validated by testing. A minimum of five readings shall be taken at different locations on the floor surface and averaged together for each 500 ft^2, or fraction thereof, equivalent floor surface. These readings shall be recorded and documented in the Facility Reference Data File (FRDF).

5.8.9.2 Resistance Surface-to-Ground (R_{tg})

Resistance from the floor surface-to-ground R_{tg} of ESD control floors, carpets or floor mats shall be greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ANSI/ESD STM7.1). The system shall be validated by testing. A minimum of five readings shall be taken at different locations on the floor surface and averaged together for each 500 ft^2, or fraction thereof, equivalent floor surface. These readings shall be recorded and documented in the FRDF.

5.8.9.3 Triboelectric Charging Limitation

ESD control floors, carpets, or floor mats shall limit and control generation and accumulation of static charges to less than +/-200 V in ESD controlled areas.

5.8.10 Electrostatic Discharge (ESD) Requirements for Raised Access Floor Systems

5.8.10.1 Resistance between Carpet Surface to Pedestal and Support Substructure

The resistance between carpet tile surface and the raised access floor pedestal and panel support substructure shall be greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms.

5.8.10.2 Contact Resistance between Panel to Access Floor Support Substructure

The contact resistance between the access floor panel system metal parts and the floor substructure shall be less than 10 ohms.

5.8.10.3 Carpet Tile Installation on Raised Access Floor Panels
Install individual carpet tiles on raised floor panels with either permanent or releasable conductive adhesive depending on the application.

5.8.10.4 Grounding of Raised Access Floor System
A minimum of four connections shall be provided per 1,000 ft^2 of installed ESD control carpeting from the carpeting undersurface and conductive adhesive to the raised access floor panel support substructure. The connections and installation method shall be in accordance with the manufacturer's recommendations, and the testing requirements of paragraphs 5.8.10.1 and 5.8.10.2.

5.8.11 Electrostatic Discharge (ESD) Protective Worksurfaces
All worksurfaces, including consoles and ESD-protected workstations and writing surfaces in all areas designated as ESD special protection areas and static-safe zones shall be static dissipative materials or electrostatic dissipative laminates.

5.8.11.1 Requirements for ESD Protective Worksurfaces
Static dissipative worksurfaces shall be provided for new or upgrade facilities unless otherwise specified. Permanent static dissipative worksurfaces shall be connected to any SRS in the area served, but not to an SPG system. Permanent ESD protective static dissipative worksurfaces shall have a resistance greater than 1.0 x 10^6 ohms point-to-point (R_{tt}) and less than 1.0 x 10^9 ohms (ESD S4.1). Permanent ESD protective worksurfaces shall have a resistance from their surface to the groundable point (R_{tg}) greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ESD S4.1).

5.8.11.2 Worksurface Types
ESD protective worksurfaces used for ESD protected workstations shall meet the requirements of MIL-PRF-87893 *Performance Specification, Workstation, ESD Control*, and MIL-W-87893 *Military Specification, Workstation, ESD Control*.

5.8.11.2.1 Type I Worksurface - Hard
Type I worksurfaces shall be constructed of rigid static dissipative materials of any color having an average Shore D hardness in excess of 90. Two male or female 0.395-in. ground snap (female) or stud (male) fasteners shall be installed on both corners on one of the longest sides of the worksurface to accommodate the male or female snap or stud fastener of the common point grounding cord. The locations of the two snaps or studs shall be 2 in. from each corner.

5.8.11.2.2 [A5] Type II Worksurface - Soft
Type II worksurfaces shall be constructed of cushioned static dissipative materials of any color having an average Shore A (ATSM D2240) hardness between 45 and 85. Two male or female 0.395-in. ground snap (female) or stud (male) fasteners shall be installed on both corners on one of the longest sides of the worksurface to accommodate the male or female snap or stud fastener of the common point grounding cord. The locations of the two male or female snaps or studs shall be 2 in. from each corner. Low-density open-cell materials are not permitted for Type II worksurfaces.

5.8.11.3 Static Dissipative Laminates
High-pressure, multilayer static dissipative laminates shall be used to cover surfaces such as plywood, fiber board, particle board, benchtops, countertops, and consoles in ESD controlled areas and special protection areas. Laminates shall include a buried conductive layer to provide for ease of grounding using a through-bolt pressure-type ESD grounding terminal.

5.8.11.4 Grounding of Laminated Surfaces
The resistance across the surface (R_{tt}) of the static dissipative laminate shall be greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms. The resistance from the surface of the laminate to ground (R_{tg}) shall be greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms (ESD S4.1). The system shall be validated through testing. A minimum of five readings of each shall be taken and averaged together. These readings and averages shall be recorded in the FRDF.

5.8.12 Static Dissipative Coatings
Permanent clear or colored static dissipative coatings used in ESD controlled areas, including painted surfaces, shall have a point-to-point resistance greater than 1.0 x 10^6 ohms and less than 1.0 x 10^9 ohms.

5.8.13 Electrostatic Discharge (ESD) Protected Workstations
ESD protected workstations are workbenches used for the maintenance and repair of ESD sensitive equipment.

5.8.13.1 ESD Protected Workstation Minimum Requirements
ESD control items at an ESD protected workstation shall be connected to a common ESD system GP and bonded to any SRS in the area served, but not to an SPG system. ESD protected workstations shall be free from all nonessential static charge generators, and provide a means of personnel grounding. Workstations shall have a grounded static dissipative work surface, and grounded static dissipative ESD control floor or mat. Storage containers located at ESD protected workstations shall be provided with ESD protection and connected to the ESD system GP. Power outlets for ESD protected workstations shall be protected with a ground fault circuit interruption (GFCI) device to minimize the risk of electrical shock to grounded personnel.

5.8.13.2 Use of Ionization
Selective use of benchtop or area ionizers is permitted at ESD-protected workstations if static generative insulator items are deemed essential and cannot be removed from the ESD protected workstation area, or the grounding of mobile personnel is not possible or creates a safety hazard.

5.8.13.3 Identification of ESD Protected Workstations
Boundaries of ESD protected workstations shall be clearly identified with highly visible ESD warning signs. Boundaries of ESD protected workstations shall be identified with yellow tape marking labels. The ESD boundary shall extend a minimum of 24 in. beyond the area where ESD sensitive items are located.

ESD warning signs shall be posted in ESD special protection areas and other ESD controlled areas. Sign labels shall be marked with an ESD sensitive electronic device warning symbol and other warning and caution labeling information appropriate for personnel safety. ESD warning signs shall be colored yellow with black marking labels and lettering.

5.9 Electromagnetic Compatibility Requirements

5.9.1 General

A comprehensive plan for the application of this standard is required to ensure the compatible operation of equipment in complex systems. Considerations in this section shall be implemented to reduce susceptibility to emissions of electronic equipment.

5.9.2 [A6] Requirements

The emission and susceptibility limits contained in MIL-STD-461 shall be applied unless otherwise specified. An electromagnetic interference (EMI) Control and Test Plan shall be developed in accordance with MIL-HDBK-237 to ensure compliance with the applicable requirements. The plan shall include a verification matrix to track the satisfaction of requirements by test, analysis, or inspection.

5.9.3 Approval

Control and Test Plans shall be submitted to the OPR for approval.

6 NOTES

6.1 Acronyms and Abbreviations

The following are acronyms and abbreviations used in this standard.

A		
	A	Ampere
	ac	alternating current
	AFSS	automated flight service station (FAA Acronym)
	ANSI	American National Standards Institute
	ARTCC	Air Route Traffic Control Center
	ASSC	airport surface surveillance capability system
	ATCT	Airport Traffic Control Tower
	AWG	American Wire Gauge
C		
	CDV	clamping discharge voltage
	cmil	circular mils
	COTS	commercial off-the-shelf
D		
	dB	Decibel
	dc	direct current
	DEB	direct earth burial
	diam	Diameter
E		
	e.g.	for example
	EES	earth electrode system
	EGC	equipment grounding conductor
	EMI	electromagnetic interference
	EMT	electrical metallic tubing
	ESD	electrostatic discharge
	et al.	and others
	etc	et cetera
F		
	FAA	Federal Aviation Administration
	FRDF	facility reference data file (FAA Acronym)
	ft	foot (feet)
G		
	GEC	grounding electrode conductors
	GFCI	ground fault circuit interruption
	GP	groundable point
H		
	Hz	hertz
	HBM	human body model

I		
	i.e.	that is
	IFR	Instrument Flight Rules (FAA Acronym)
	IMC	intermediate metal conduit
	in.	inch
	IEEE	Institute of Electrical and Electronics Engineers
K		
	kA	kiloampere
	kcmil	thousand circular mils
	kHz	kilohertz
L		
	LAN	local area network
	lb	pound
	LPGBS	Lightning Protection, Grounding, Bonding and Shielding
	L-G	Line-to-Ground
	L-L	Line-to-Line
	L-N	Line-to-Neutral
	LLWAS	low level wind shear alert system (FAA Acronym)
M		
	m	meter
	mm	millimeter
	mA	milliampere
	mΩ	milliohm
	MΩ	megohm
	MCOV	Maximum continuous operating voltage
	MHz	megahertz
	MPG	multipoint ground system
	MPGP	multipoint ground plate
	µs	microsecond
N		
	NAS	National Airspace System
	NAVAIDS	navigation aids
	NEC	National Electrical Code
	NEMA	National Electrical Manufacturers Association
	NFPA	National Fire Protection Association
	ns	nanosecond
O		
	OCPD	overcurrent protective device
	OM	outer marker (FAA Acronym)
	OPR	Office of Primary Responsibility
	Ω	ohm
P		
	PIV	peak inverse voltage
	PVC	polyvinyl chloride

R		
	RF	radio frequency
	RGS	rigid galvanized steel
	RFI	radio-frequency interference
	RMC	rigid metal conduit
	rms	root-mean-square
	R_{slope}	slope resistance
	R_{tg}	surface-to-ground resistance
	R_{tt}	surface resistance
	RVR	runway visual range (FAA Acronym)
S		
	SDM	service disconnecting means
	SPD	surge protective device
	SPG	single point ground system
	SPGP	single point ground plate
	SRGG	signal reference ground grid
	SRGP	signal reference ground plane
	SRM	safety risk management
	SRS	signal reference structure
	SSC	system support center (FAA Acronym)
T		
	TELCO	telephone company (FAA Acronym)
	ton	unit of mass or weight
	TRACON	terminal radar approach control facility
	TVSS	transient voltage surge suppressors
U		
	UL	Underwriters Laboratories
	UPS	uninterruptible power supply
V		
	V	volt
	V_{dc}	volts direct current
	VOR	very high frequency (VHF) omni directional range (FAA Acronym)
W		
	λ	Frequency Wavelength

6.2 Guidelines and Reference Notes

[A1] **Paragraph 4.2.1.1**
See FAA-HDBK-010 for evaluation, inspection, and testing procedures.

[A2] **Paragraph 4.2.3.4.1**
See MIL-STD-889, paragraphs "Precautions and methods for joining" and "Recommended Treatments in Order of Protective Effectiveness" for additional guidance for completing bond joints where base metals for couples are not permitted in Table 1.

[A3] **Paragraph 4.4.2**
The site survey geotechnical investigation data and EES design configuration are expected to be documented and retained within the facility's as-built documentation set, in accordance with FAA Order 630.45, Facility Reference Data File.

[A4] **Paragraph 4.4.4.4**
Access wells located in nontraffic areas should be medium duty rated per AASHTO H-20 design load criterion up to 40,000 lb. Access wells subject to vehicular traffic should be traffic rated per AASHTO M306 proof loading criterion up to 100,000 lb. Access wells subject to aircraft loading should be Airport rated per AASHTO M306 proof loading criterion up to 200,000 lb.

[A5] **Paragraph 5.8.11.2.2**
Guidance for measurement of material hardness properties is in ATSM-D2240, Standard Test Method for Rubber Property - Durometer Hardness, ASTM International, West Conshohocken, PA, 2015, www.astm.org.

[A6] **Paragraph 5.9.2**
Guidance for EMI protection is in MIL-HDBK-253, and for ESD in NFPA 77, DODHDBK-263, DOD-STD-1686, and IEEE 1100.

6.3 Version Cross-Reference

Due to the major reorganization of FAA-STD-019F it is not feasible to provide an exact cross-reference between this standard and the previous versions of FAA-STD-019. The OPR should be consulted for assistance in determining references to the original requirements in previous editions of FAA-STD-019.

6.4 Bibliography

[B1] NFPA 70, National Electrical Code, National Fire Protection Association, Current Edition.

[B2] NFPA 75, Standard for the Fire Protection of Information Technology Equipment, National Fire Protection Association, Current Edition.

[B3] NFPA 780, Standard for the Installation of Lightning Protection Systems Handbook, National Fire Protection Association, Current Edition.

[B4] IEEE 1100, IEEE Recommended Practice for Powering and Grounding Electronic Equipment, Institute of Electrical and Electronics Engineers, Inc., Current Edition.

[B5] IEEE C2, National Electrical Safety Code, Institute of Electrical and Electronics Engineers, Inc., Current Edition.

[B6] MIL-HDBK-419, Department of Defense, Military Handbook: Grounding, Bonding, and Shielding for Electronic Equipments and Facilities, Volume I, Current Edition.

[B7] MIL-HDBK-419, Department of Defense, Military Handbook: Grounding, Bonding, and Shielding for Electronic Equipments and Facilities, Volume II, Current Edition.

[B8] MIL-HDBK-237, Department of Defense, Military Handbook: Electromagnetic Environmental Effects and Spectrum Supportability Guidance for the Acquisition Process, Current Edition.

[B9] MIL-STD-188-124, Department of Defense, Military Standard: Grounding, Bonding and Shielding for Common Long Haul/Tactical Communication Systems Including Ground Based Communications Electronics Facilities and Equipments, Current Edition.

[B10] MIL-STD-461, Department of Defense, Interface Standard: Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, Current Edition.

[B11] MIL-STD-464, Department of Defense, Interface Standard: Electromagnetic Environmental Effects Requirements for Systems, Current Edition.

[B12] MIL-STD-889, Department of Defense, Military Standard: Dissimilar Metals, Current Edition.

[B13] MIL-STD-962, Department of Defense, Standard Practice: Format and Content, Current Edition.

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INSTALLING SEISMIC RESTRAINTS FOR MECHANICAL EQUIPMENT

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December 2002

Developed by the Vibration Isolation and Seismic Control Manufacturers Association under a cooperative agreement between the Federal Emergency Management Agency and the American Society of Civil Engineers

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TABLE OF CONTENTS

INTRODUCTION	**2**
EQUIPMENT	**4**
Air Compressors	4
Air Conditioning Units and Heat Pumps	6
Air Handling Units	8
Air Separators	11
Boilers, Furnaces, Humidifiers, Water Heaters	12
Chillers	14
Coils and Heat Exchangers	16
Condensers and Condensing Units	18
Cooling Towers, Evaporative Coolers, Fluid Coolers	20
Fans	22
Heaters	23
Pumps	26
Tanks and Gas Cylinders	28
VAV Boxes, Duct Silencers, Fan-coil Units	30
ATTACHMENT TYPES	**32**
Rigid Floor-mounted/Pad-mounted Attachment	32
Roof-mounted Attachment	48
Suspended Attachment	62
Vibration-isolated/Floor-mounted Attachment	77
Wall-mounted Attachment	88
ANCHORS	**96**
General	96
Cast-in-place Anchors	103
Lag Bolts	104
Masonry and Drywall Anchors	106
Steel Bolt Connections	114
Welding	119
Anchor Sizes for Equipment Less than 400 Pounds	121
SPECIAL CASES	**124**
Cables	124
Control Panels	130
Housekeeping Pads	135
Residential Equipment	139
ANCHOR SELECTION GUIDE	**141**
GLOSSARY	**149**
INDEX	**157**

INTRODUCTION

This guide shows equipment installers how to attach mechanical equipment to a building to minimize earthquake damage. Many attachment examples are presented, to include anchoring and the use of special devices called *seismic restraint devices.*

Seismic restraint devices include vibration isolation systems, cable or strut suspension systems, roof attachment systems, and steel shapes.

Please note that this guide does not replace:

- Printed instructions shipped with the equipment.
- Instructions in contract drawings and specifications.
- Code-required, industry-accepted practices.
- Orders from your supervisor.
- Seismic Restraint Device Submittals.

Please note that this guide does not cover:

- Non-building structural framing required to elevate equipment above the floor.

If you have questions about any information in this guide, check with your supervisor.

This guide contains these sections:

- *Equipment:* Arranged according to different kinds of mechanical equipment such as Air Compressors, Cooling Towers, Pumps, etc.
- *Attachment Types:* Gives instructions on installing equipment in different arrangements known as *attachment types.*
- *Anchors:* Shows many many different types of anchors used to connect equipment to a building.
- *Special Cases:* Covers housekeeping pads, cable assemblies, supports for control panels, and residential equipment.

Start with the Equipment section that best represents the equipment you are installing.

- Use the Table of Contents to find the correct starting page.

- Using the table in the Equipment section, find the type of equipment you are installing in column 1. The method for installing this equipment is shown in column 2 and the attachment type is shown in column 3. An example is shown below:

column 1	column 2	column 3
Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any box or cabinet fan	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*

- Turn to the page number for the attachment type in column 3.
- If you are not sure which attachment type is correct, ask your supervisor.

Follow the instructions for the attachment type you have selected. These instructions will refer you to the correct anchor section so you can make the connection to the building structure.

All instructions in this guide are arranged in order using numbered steps.

- Please follow every step in the sequence shown.

Special precautions are marked:

A flag means you should take special care before continuing. Read all the information next to a flag before attaching the equipment.

A warning sign means you can cause serious damage to the building, the device, or the equipment if you do not follow the instructions exactly.

A book means you should refer to the manufacturer's printed instructions before continuing.

Note that a Glossary and an Index are also available to facilitate use of this guide.

EQUIPMENT

Air Compressors

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 1: Housed air compressor (water-cooled).

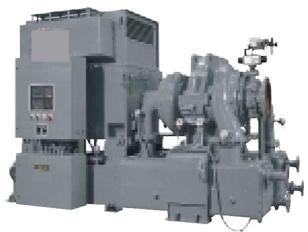


Figure 2: Air compressor skid-mounted (water-cooled).

Figure 3: Air compressor with vertical tank (air-cooled).

Figure 4: Reciprocating type air compressor with horizontal tank (air-cooled).

Figure 5: Skid-mounted equipment including large filter dryers.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any compressor except housed or skid-mounted	Mounted directly to the floor	Rigid *Go to page 32*
	Floor-mounted on vibration isolators using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*
Housed or skid-mounted compressors	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*

Table 1: Air compressor installation types.

Air Conditioning Units and Heat Pumps

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 6: Small rooftop air conditioning unit or heat pump (air-cooled).

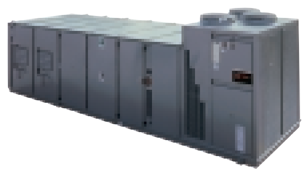


Figure 7: Large rooftop air conditioning unit (air-cooled).

Figure 8: Indoor air conditioning unit or heat pump (floor-mounted or suspended with remote condenser).

Figure 9: Self-contained water-cooled unit (floor-mounted or raised floor-mounted).

Figure 10: Through-the-wall air conditioning unit or heat pump.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any AC unit or heat pump	Mounted directly to the floor	Rigid *Go to page 32*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
	Floor-mounted on vibration isolators using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*
Self-contained unit; use manufacturer's base designed for raised floor	Installed on a raised floor	Raised floor *Go to page 43*
Any rooftop unit	Roof-mounted on a post and beam	Post and beam *Go to page 48*
	Connected to a manufactured isolation curb on a post and beam	Isolated curb on a post and beam *Go to page 58*
	Vibration isolated on a post and beam	Isolation springs on a post and beam *Go to page 60*
	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb *Go to page 51*
	Directly connected to a wood roof curb	Wood curb *Go to page 57*
Indoor AC unit or heat pump	Suspended from building structure above with rods and cables	Rods and cables *Go to page 62*
	Suspended from building structure above with angles	Suspended with angles *Go to page 68*
	Suspended from building structure above with isolators, rods, and cables	Isolator rods and cables *Go to page 70*
Through-the-wall unit	Supported by the wall	Wall-mounted with angles *Go to page 90*

Table 2: AC unit and heat pump installation types.

Air Handling Units

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 11: Small rooftop air handling unit.

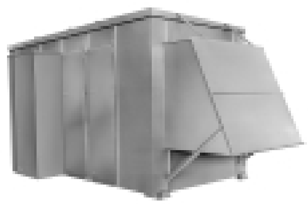


Figure 12: Large rooftop air handling unit.

Figure 13: Horizontal indoor air handling unit (floor-mounted or suspended).

Figure 14: Vertical indoor air handling unit (floor-mounted).

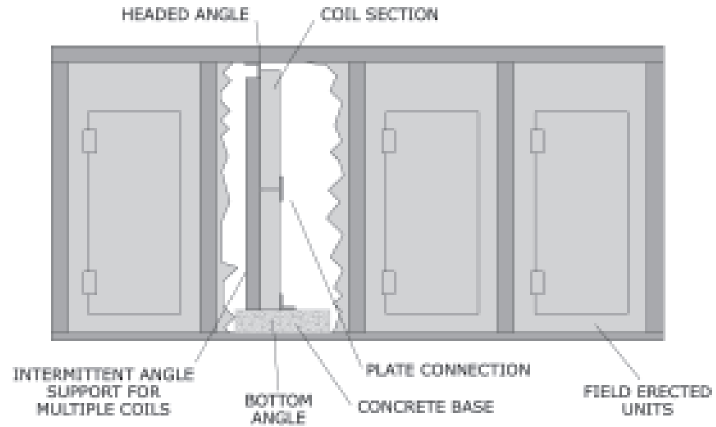


Figure 15: Built-up air handling units.

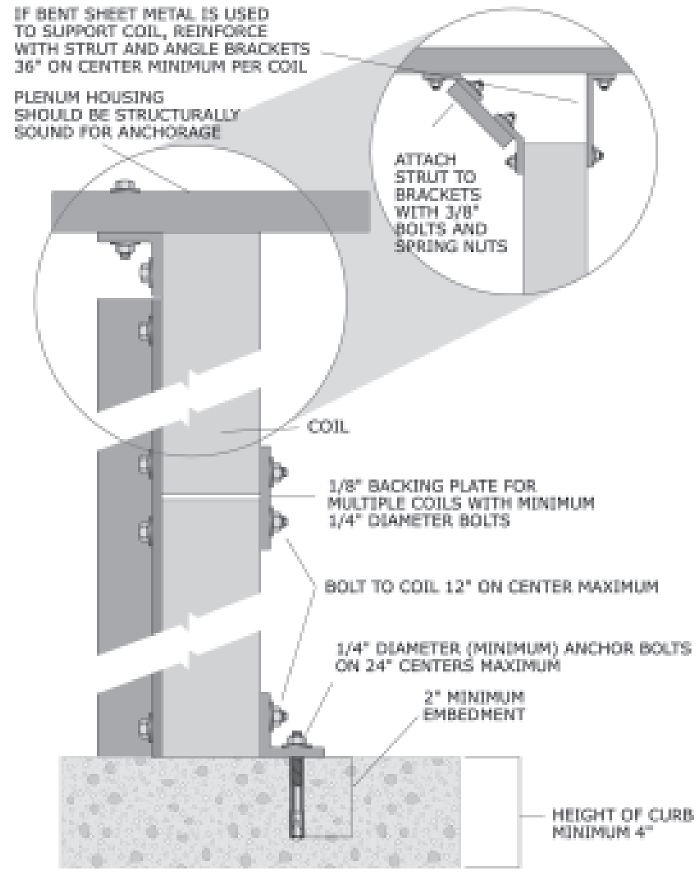


Figure 16: Coils in air handling units.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Indoor air handling unit with a rigid base	Mounted directly to the floor	Rigid *Go to page 32*
Indoor air handling unit	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
	Suspended from structure above with rods and cables	Rods and cables *Go to page 62*
	Suspended from structure above with angles	Suspended with angles *Go to page 68*
	Suspended from structure above with vibration isolation, rods, and cables	Isolator rods and cables *Go to page 70*
Weight-limited rooftop unit (see manufacturer's literature)	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb *Go to page 51*
	Directly connected to a wood roof curb	Wood curb *Go to page 57*
Any rooftop unit	Connected to a manufactured vibration isolation curb on a post and beam	Isolated curb on a post and beam *Go to page 58*
	Roof-mounted on a post and beam	Post and beam *Go to page 48*
Large rooftop unit	Vibration isolation on a post and beam	Isolation springs on a post and beam *Go to page 60*
Any air handling unit	Floor-mounted on vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*

Table 3: Air handling unit installation types.

Air Separators

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 17: Air separator (floor-mounted).

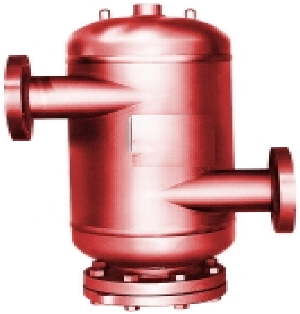


Figure 18: Air separator (suspended).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any unit	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
	Suspended from the building structure above with rods and cables	Rods and cables *Go to page 62*
	Suspended from the building structure above with angles	Suspended with angles *Go to page 68*
	Supported from the wall with angles	Wall-mounted with angles *Go to page 90*

Table 4: Air separator installation types.

Boilers, Furnaces, Humidifiers, and Water Heaters

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 19: Small boiler.

Figure 20: Humidifier.

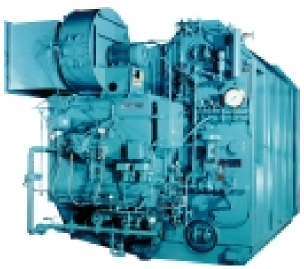


Figure 21: Water-tube (shown) or fire-tube boiler.

Figure 22: Flextube boiler.

Figure 23: Furnace.

Figure 24: Water heater.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any boiler or humidifier	Mounted directly to the floor	Rigid *Go to page 32*
Any boiler, hot water heater, or furnace	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
Residential furnace	Furnace supported and restrained by rigid ductwork connections	Strap down similar to water heater *Go to page 90*
Residential water heater	Strapped to the wall	Wall-mounted with straps *Go to page 90*
Humidifier	Mounted directly to the wall	Wall-mounted *Go to page 88*

Table 5: Boiler, furnace, humidifier, and water heater installation types.

Chillers

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

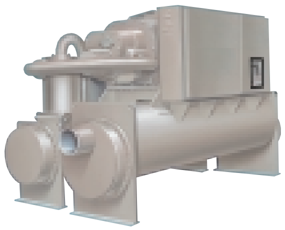


Figure 25: Centrifugal chiller (water-cooled).

Figure 26: Chiller with screw compressors (air-cooled).

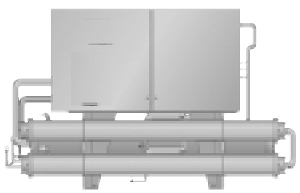


Figure 27: Indoor chiller with scroll or screw compressors (water-cooled).

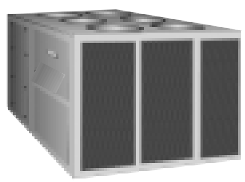


Figure 28: Small chiller with scroll and compressors (air-cooled).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any chiller	Mounted directly to the floor or concrete pad	Rigid *Go to page 33*
	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*
Roof-mounted unit	Roof-mounted on a post and beam	Post and beam *Go to page 48*
	Vibration isolation on a post and beam	Vibration-isolated on a post and beam *Go to page 60*

Table 6: Chiller installation types.

Coils and Heat Exchangers

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

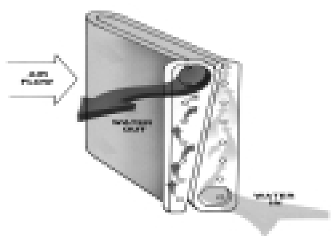


Figure 29: Duct-mounted coil.

Figure 30: A-coil.

Figure 31: Plate and frame heat exchanger.

Figure 32: Shell and tube heat exchanger.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Heat exchanger [1]	Mounted directly to the floor or concrete pad	Rigid *Go to page 32*
Duct-mounted coil	Suspended from the building structure above with angles	Suspended with angles *Go to page 68*
A-coil	Sheet metal screws to furnace and sheet metal ducts	N/A
Coils in built-up plenums	Plenum-mounted coils	*See Figure 16, page 9*

[1] This guide does not address structural frames required to elevate the heat exchanger above the floor.

Table 7: Coil and heat exchanger installation types.

Condensers and Condensing Units

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 33: Condenser/ condensing unit (side condenser).

Figure 34: Condenser/ condensing unit (totally enclosed).

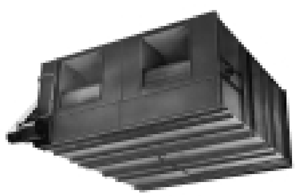


Figure 35: Indoor condenser/ condensing unit (see Air Handling Units for installation options).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any condensing or condenser unit	Mounted directly to the floor or concrete pad	Rigid *Go to page 32*
	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*
Roof-mounted unit	Roof-mounted on a post and beam	Post and beam *Go to page 48*
	Connected to a manufactured vibration isolation curb on a post and beam	Isolated curb on a post and beam *Go to page 58*
Small rooftop unit	Directly connected to a wood roof curb	Wood curb *Go to page 57*

Table 8: Condenser and condensing unit installation types.

Cooling Towers, Evaporative Coolers, and Fluid Coolers

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 36: Fluid cooler cross flow with self-contained sump.

Figure 37: Cooling tower with self-contained sump.

Figure 38: Evaporative cooler.

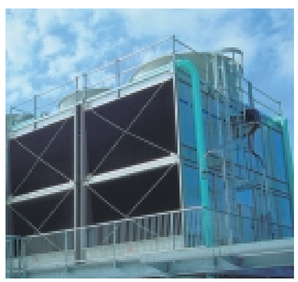


Figure 39: Large cooling tower.

Step 2: Select the type of attachment to building

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any unit with a rigid base or pedestal	Mounted directly to floor or concrete sump	Rigid *Go to page 32*
Any unit with a self-contained sump	Roof-mounted on a post and beam	Post and beam *Go to page 48*
Fluid cooler, evaporative cooler, or cooling tower with a self-contained sump	Vibration isolated on a post and beam	Vibration-isolated on a post and beam *Go to page 60*
Any unit with a structural base	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*
Evaporative cooler	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
Roof-mounted evaporative cooler	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb *Go to page 51*

Table 9: Cooling tower, evaporative cooler, and fluid cooler installation types.

Fans

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

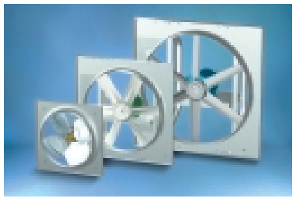


Figure 40: Wall propeller fan.

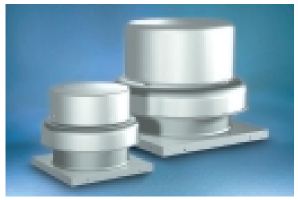


Figure 41: Rooftop fan.

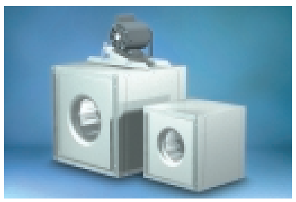


Figure 42: Indoor box fan.

Figure 43: Indoor ceiling fan.

Figure 44: Axial fan.

Figure 45: Axial fan with remote motor.

Figure 46: Centrifugal fan.

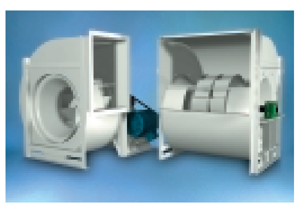


Figure 47: Industrial skid-mounted blower.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Centrifugal or industrial skid-mounted blower	Mounted directly to the floor	Rigid *Go to page 32*
Any box or cabinet fan	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
Rooftop fan	Directly connected to a sheet metal curb with nailer	Pre-manufactured curb *Go to page 51*
	Directly connected to wood roof curb	Wood curb *Go to page 57*
	Vibration isolation on a post and beam	Vibration-isolated on a post and beam *Go to page 60*
Any propeller, box, cabinet, or axial fan	Suspended from the building structure above with rods and cables	Rods and cables *Go to page 62*
	Suspended from the building structure above with angles	Suspended with angles *Go to page 68*
	Suspended from the building structure above with isolators, rods and cables	Isolator rods and cables *Go to page 70*
Centrifugal or skid-mounted blower unit	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*
Propeller fan	Mounted directly to the wall	Wall-mounted *Go to page 88*
	Vibration isolation from the building structure	Vibration-isolated off the wall *Go to page 93*

Table 10: Fan installation types.

Heaters

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 48: Electric unit heater.

Figure 49: Water or steam unit heater.

Figure 50: Gas unit heater.

Figure 51: Gas-fired unit heater (see Air Handling Units for installation options).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any unit heater	Suspended from the building structure above with rods and cables	Rods and cables *Go to page 62*
	Suspended from the building structure above with angles	Suspended with angles *Go to page 68*
	Suspended from the building structure above with isolators, rods, and cables	Isolator rods and cables *Go to page 70*
	Supported off the wall with a bracket	Wall-mounted with angles *Go to page 90*
Relatively thin unit heaters	Suspended from the building structure with two rods and cables	Double rods and cables *Go to page 75*

Table 11: Heater installation types.

Pumps

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

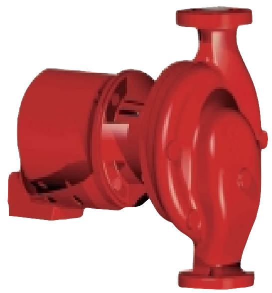


Figure 52: In-line pump.

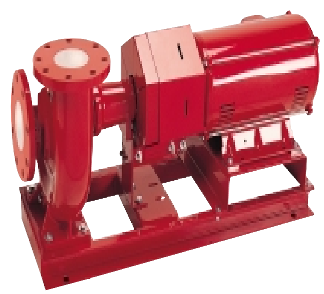


Figure 53: Horizontal end-suction or split-case pump.

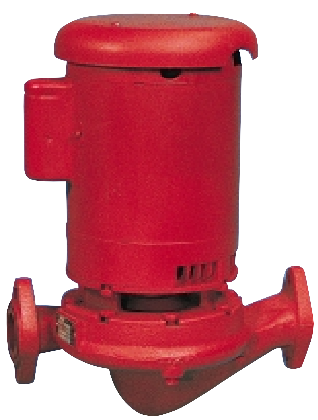


Figure 54: Close-coupled pump.

Figure 55: Vertical pump.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Base-mounted pump including end-suction pump and vertical pump	Mounted directly to the floor	Rigid *Go to page 32*
Base-mounted pump including end-suction pump	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
	Floor-mounted vibration isolation using restrained springs or open springs and snubbers	Vibration-isolated *Go to page 77*
In-line or close-coupled pump	Supported off the floor with a steel angle	Rigid with angles *Go to page 36*
	Suspended from the building structure above with rods and cables	Rods and cables *Go to page 62*
	Suspended from the building structure above with angles	Suspended with angles *Go to page 68*
	Suspended from the building structure above with isolators, rods and cables	Isolator rods and cables *Go to page 70*
	Mounted directly to the wall	Wall-mounted *Go to page 88*
	Supported off the wall with an angle bracket	Wall-mounted with angles *Go to page 90*

Table 12: Pump installation types.

Tanks and Gas Cylinders

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

Figure 56: Small expansion tanks or water tanks (with rolled steel plate base).

Figure 57: Expansion tanks, water storage tanks, on legs.

Figure 58: Water softeners.

Figure 59: Vertical tanks.

Figure 60: Horizontal tanks including concrete-lined tanks.

Figure 61: Gas cylinders.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment [1]	*How is equipment to be installed?*	*Attachment Type*
Tanks with attachment stands, legs or brackets	Mounted directly to the floor	Rigid *Go to page 32*
Tanks with rolled steel plate bases	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
Tanks less than 4 feet in diameter with a flat bottom or gas cylinders	Tanks built into a plate and frame	Strut and frame *Go to page 46*
Tanks less than 2 feet in diameter	Attached to the wall with straps	Wall-mounted with angles or straps *Go to page 90*
Tanks or gas cylinders	Chained to the wall	Wall-mounted with chains *Go to page 95*

[1] This guide does not address structural frames required to elevate tanks.

Table 13: Tank and gas cylinder installation types.

VAV Boxes (Terminal Units), Duct Silencers, and Fan-coil Units

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify equipment

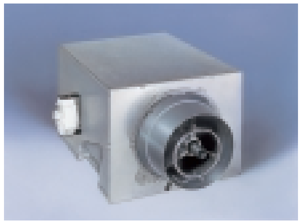


Figure 62: VAV damper.

Figure 63: VAV box with fan (series or parallel).

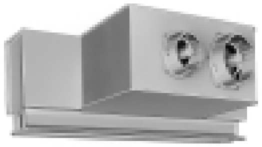


Figure 64: Dual duct box.

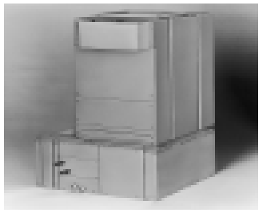


Figure 65: Vertical fan-coil unit.

Figure 66: Horizontal fan-coil unit.

Figure 67: Duct silencer.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Fan-coil unit	Mounted directly to the floor	Rigid *Go to page 32*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 36*
Any VAV box, duct silencer, or fan-coil unit	Suspended from the building structure above with rods and cables	Rods and cables *Go to page 62*
	Suspended from the building structure above with angles	Suspended with angles *Go to page 68*
	Suspended from the building structure above with isolators, rods, and cables	Isolator rods and cables *Go to page 70*
Any VAV box, duct silencer, or fan-coil unit weighing less than 150 pounds	Suspended from the building structure above with two attachment angles	Suspended with two angles *Go to page 75*

Table 14: VAV box (terminal unit), duct silencer, and fan-coil unit installation types.

ATTACHMENT TYPES

This section gives instructions on attaching equipment in many different arrangements. The attachment types are:

- Rigid Floor-mounted/Pad-mounted (this page).
- Roof-mounted (page 48).
- Suspended (page 62).
- Vibration-isolated/Floor-mounted (page 77).
- Wall-mounted (page 88).

Rigid Floor-mounted/Pad-mounted Attachment

The six ways to rigidly attach equipment to a floor are:

- Directly to the floor/pad (this page).
- Using additional structural steel shapes that transfer load to the building floor (page 36).
- Using bumpers to restrict horizontal movement (page 41).
- Beneath a raised floor (page 43).
- At a single point—light equipment only (page 45).
- Using a strut and plate frame—tanks and gas cylinders only (page 46).

Directly to the floor/pad

Equipment may be bolted or welded to the building floor or pad. To bolt to concrete, use post-installed anchors, embedded headed studs or embedded J-bolts.

Attachment of equipment with sheet steel housings is shown in Figure 69 (page 33).

Attachment of equipment with a steel structural framing or base is shown in Figure 70 (page 34).

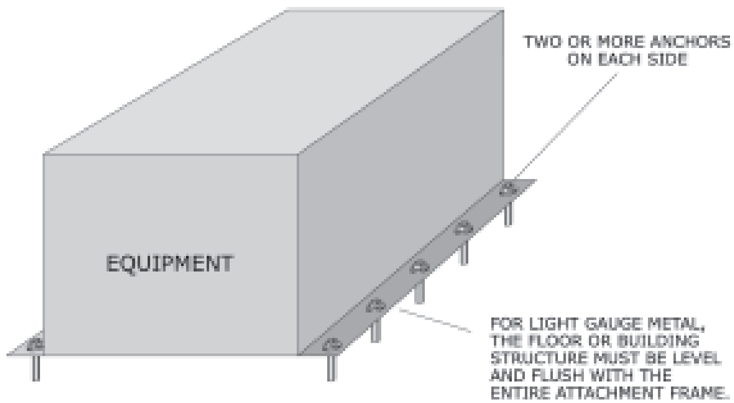


Figure 68: Direct attachment of equipment with sheet steel housing to a building.

Do not add shims under equipment with sheet steel housings as shown in Figure 68 above. If the concrete floor/pad is irregular, reinforce housing with angles as shown in Figure 72 (page 37).

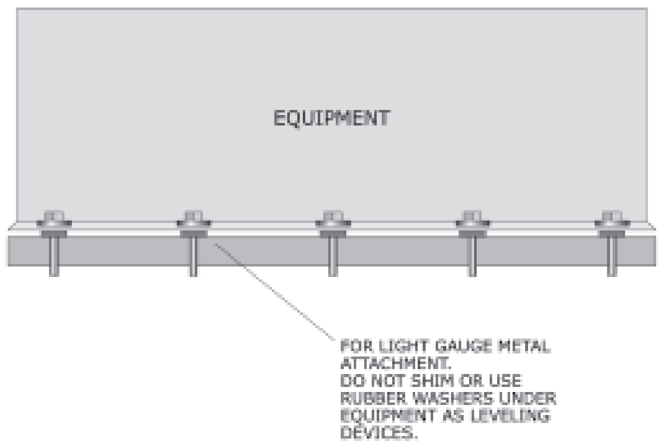


Figure 69: Side view of equipment with sheet steel housing.

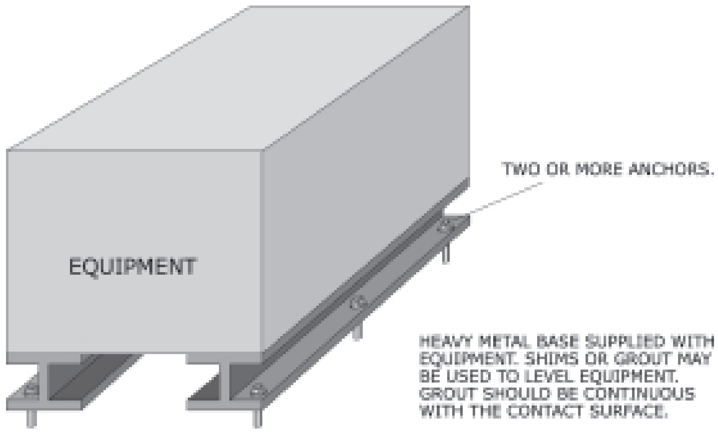


Figure 70: Direct attachment of equipment with structural steel frame or base to a building.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.

You may drill additional holes into the equipment assembly or building steel beams as shown on construction drawings or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided. DO NOT DRILL OVERSIZED HOLES.

New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 71 (page 35), if necessary.

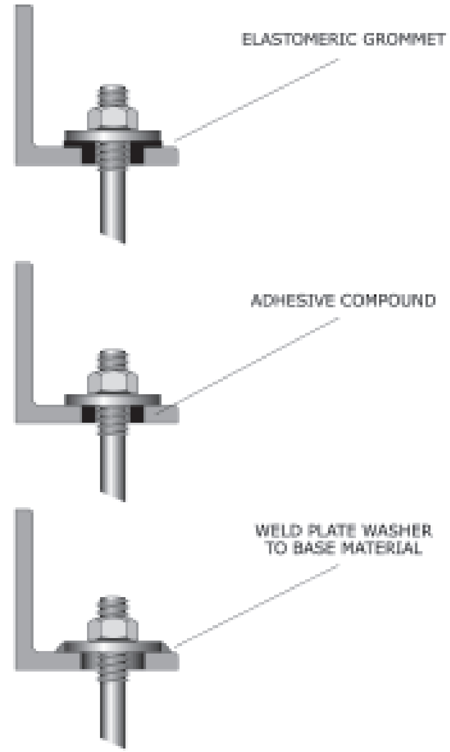


Figure 71: Three options to repair oversized holes.

Step 2: Install anchors

If the equipment is to be anchored to concrete, drill and install post-installed anchors or pour concrete with cast-in-place studs or J-bolts (see Anchors, page 96).

If the equipment is to be bolted to steel, drill holes in the steel as shown on construction drawings or the manufacturer's instructions.

Step 3: Move equipment into place

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.

Step 4: Attach nuts or weld equipment

Attach nuts to the anchor/bolt and torque.

Weld equipment to steel beams or embedded plates (page 119).

Piping, ductwork, and raceways may be connected.

END OF ATTACHMENT.

Using additional structural steel shapes

Attach additional structural shapes to the equipment with bolts and then attach steel shapes to the building with concrete anchors, steel bolts, or welding. When bolting to concrete, use post-installed anchors, embedded headed studs, or embedded J-bolts.

Five different configurations for using angles to attach equipment to the building structure are shown in the following figures.

- Full-size angles on each side of equipment: Figure 72 (page 37).
- Four or more angles on each side of equipment bolted to the concrete floor/pad: Figure 73 (page 38).
- Four or more angles welded to equipment and bolted to the floor/pad: Figure 74 (page 38).
- Four or more angles on each side of equipment welded to embedded plates: Figure 75 (page 39).
- Three or more angles used to bolt down equipment with a round base: Figure 76 (page 39).

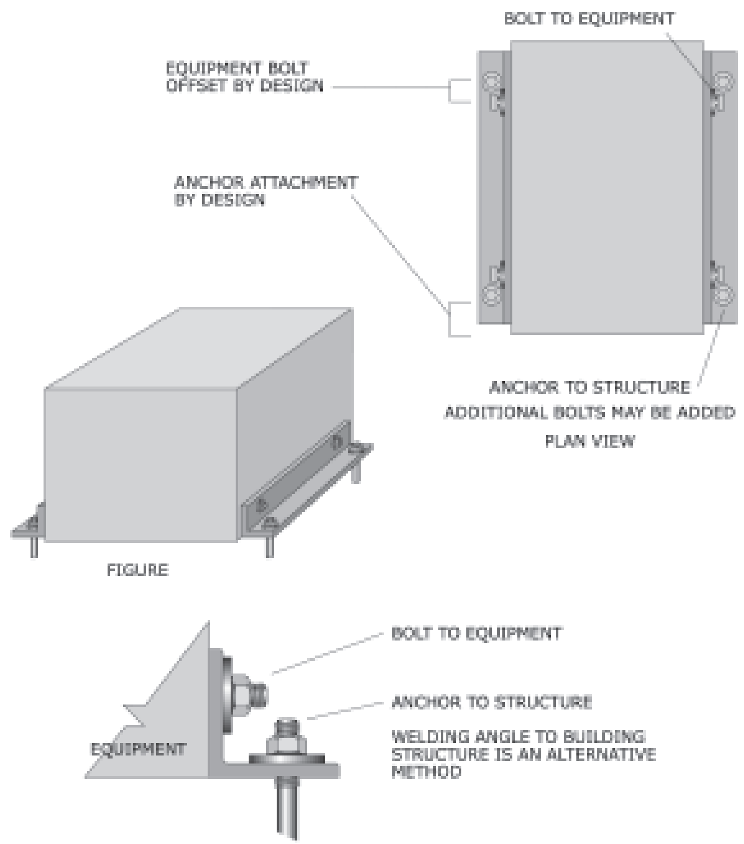


Figure 72: Two angles used to attach the equipment to the building.

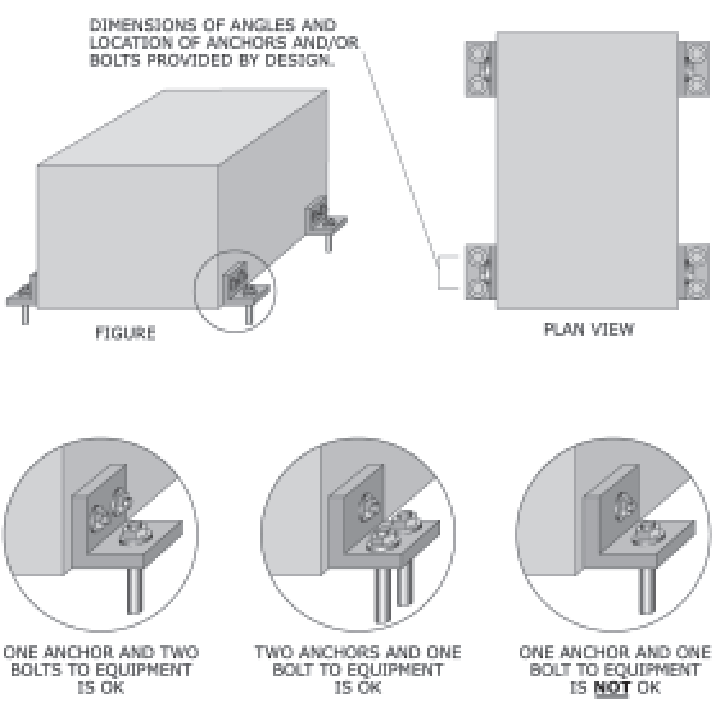


Figure 73: Four or more angles used to attach the equipment to the building.

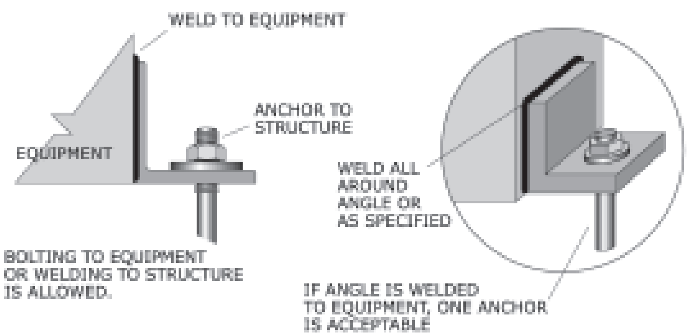


Figure 74: Four or more angles welded to equipment and bolted to the floor/pad.

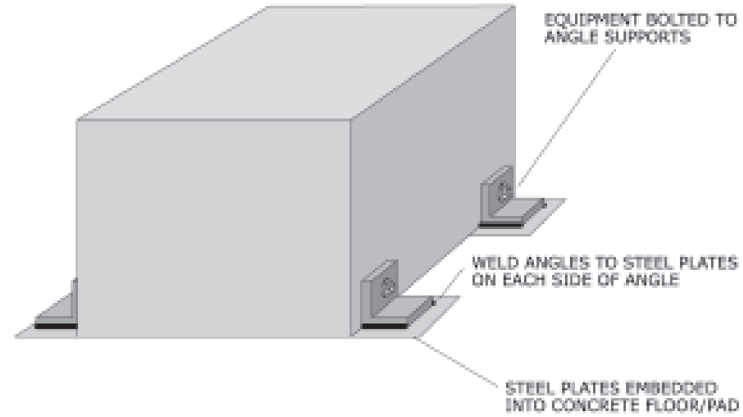


Figure 75: Four or more angles on each side of equipment welded to embedded plates. Figure 150 (page 119) gives examples of embedded steel plates.

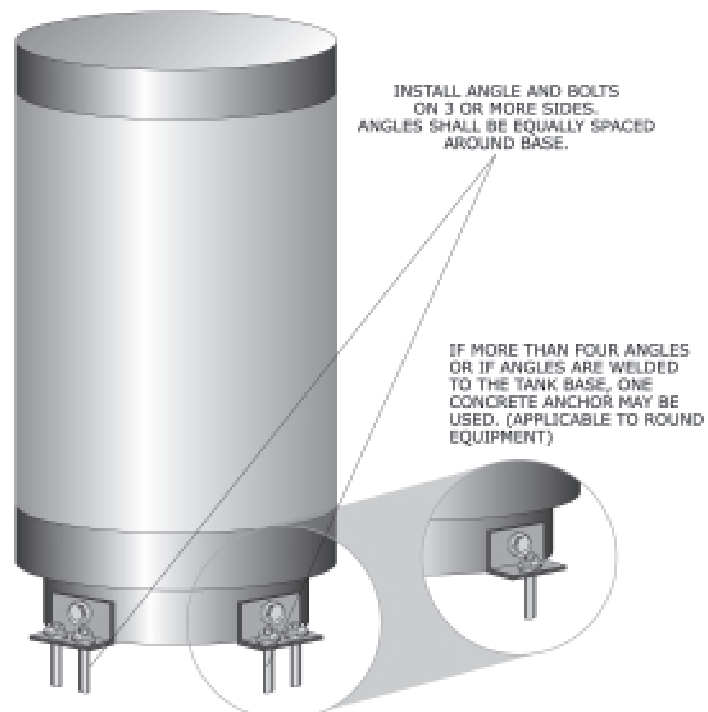


Figure 76: Three or more angles used to bolt down equipment with a round base.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.

You may drill additional holes into the equipment assembly or building steel beams as shown on construction drawings or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO THE EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided. DO NOT DRILL OVERSIZED HOLES.

New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 71 (page 35), if necessary.

Step 2: Install anchors

If the equipment is to be anchored to concrete, drill and install post-installed anchors or pour concrete with embedded studs or J-bolts (see Anchors, page 96).

If the equipment is to be bolted to steel, drill holes in the steel as shown on construction drawings or the manufacturer's instructions.

Step 3: Move the equipment into place

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.

You may bolt or weld angles to the equipment before moving the equipment into place.

Step 4: Attach nuts or weld equipment

Attach nuts to the anchor/bolt and torque (see Anchors, page 96 or Welding, page 119).

Piping, ductwork, and raceways may be connected.

END OF ATTACHMENT.

Using bumpers to restrict horizontal movement

Use this attachment type when equipment is mounted to a concrete inertia base or steel frame, but:

- The base is not attached to the building, or
- The equipment has a rigid base with a flat surface near the bottom.

Bumpers are used to restrain the base from moving horizontally when there is no chance that the equipment will tip over. Bumpers are only bolted to the building structure. Use post-installed anchors to bolt to concrete, as shown in Figures 77 and 78 (below).

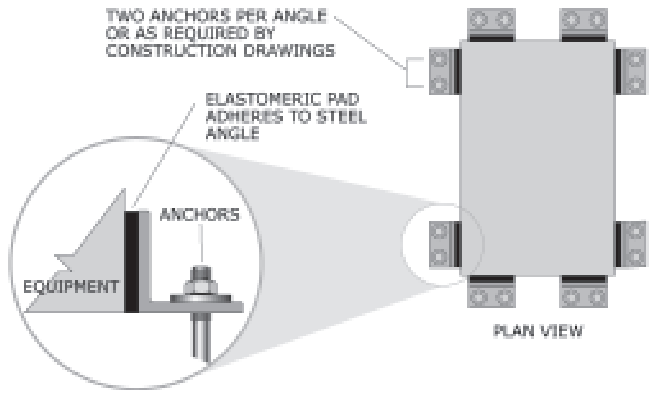


Figure 77: Equipment installed with bumpers.

If anchors are near a joint in the concrete, see detail in Figure 78.

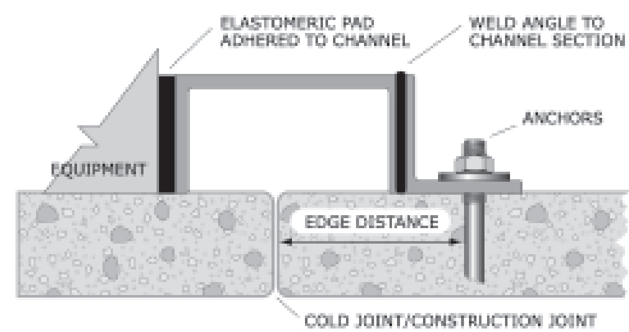


Figure 78: Alternate installation detail of bumpers installed near a concrete joint.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the bumpers in place and mark the holes.
- Use measurements and construction drawings to lay out the bolt hole pattern.

Step 2: Install anchors

See Anchors (page 96). If the anchors are near a concrete joint, refer to the detail in Figure 78 (page 41).

Step 3: Install bumpers

Step 4: Attach nuts to the anchor/bolt and torque

See Anchors, page 96. Figure 78 shows equipment restrained with bumpers next to a cold joint. Notice in Figure 79 below that the application is near a concrete joint.

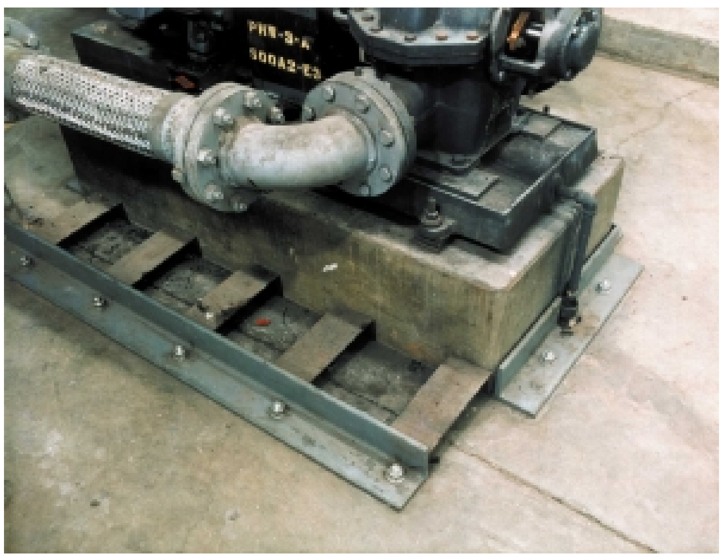


Figure 79: Equipment restrained with bumpers.

END OF ATTACHMENT.

Beneath a raised floor

Air conditioning units for computer spaces typically move air through a raised floor. A stand rated for the weight of the air conditioning unit and laterally braced to withstand seismic loads must be provided. Equipment is rigidly attached to the stand and the stand is rigidly bolted to the floor beneath the raised floor. Portions of the raised floor are removed to allow installation of the stand and equipment as shown in Figure 80 (below).

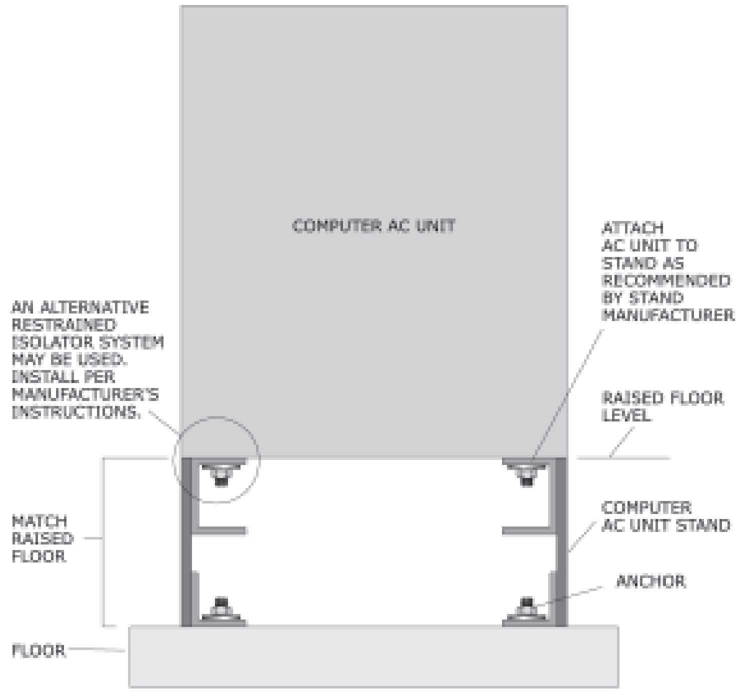


Figure 80: Air conditioning unit for a raised floor.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor using one of the following methods:

- Set the frame in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

Step 2: Install anchors

See Anchors, page 96. Set the frame in place and apply nuts to the anchor/bolt and torque.

Step 3: Move the equipment into place

Bolt equipment to the frame (see Steel Bolt Connections, page 114). You may drill additional holes into the equipment assembly or building steel beams as shown on construction drawings or the manufacturer's instructions.

New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 71 (page 35), if necessary.

Piping, ductwork, and raceways may be connected.

END OF ATTACHMENT.

At a single point—light equipment only

Air separators or inline pumps weighing less than 400 pounds may be supported on both the inlet and outlet using a floor support as shown in Figure 81 (below). A single support may be used if the equipment weighs less than 150 pounds. A rigid connection with rods and cables supported from the building structure above is optional.

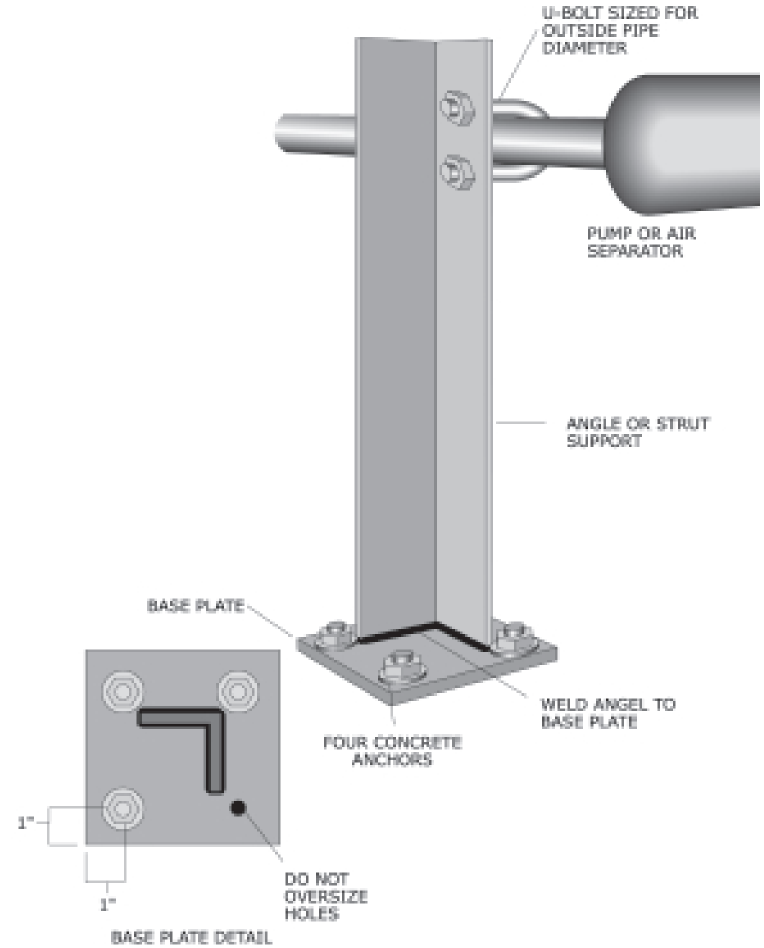


Figure 81: Angle floor support.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern of the base plate on the floor using one of the following methods:

- Set the base plate in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

Step 2: Install anchors

Install post-installed anchors as described in Anchors (page 96). Set the base plate with the angle support in place. Apply nuts to the anchor/bolt and torque.

Step 3: Attach piping

Attach piping to the angle with a U-bolt (see Steel Bolt Connections, page 114.)

END OF ATTACHMENT.

Using a strut and plate frame—tanks and gas cylinders only

Figure 82: Small gas cylinder storage.

Step 1: Determine where to bolt the equipment

Accurately draw bolting pattern of the strut frame on the floor using one of the following methods:

- Set the base plate in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

Step 2: Install anchors

Install post-installed anchors as described in Anchors (page 96). Set the bottom frame in place. Apply nuts to the anchor/bolt and torque.

Step 3: Complete frame and plate assembly

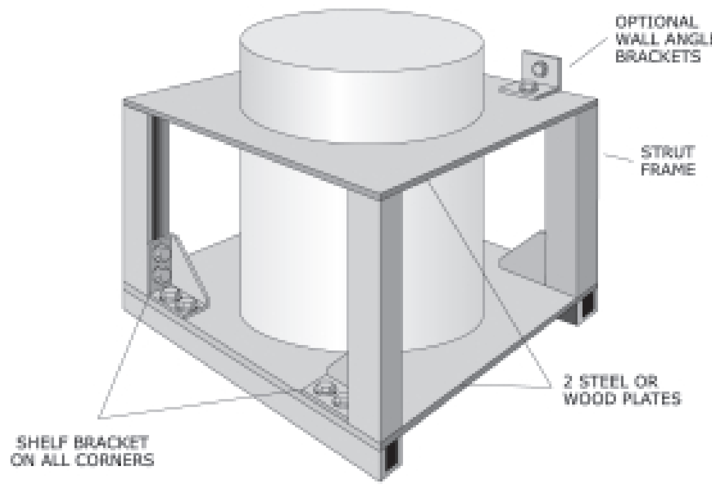


Figure 83: Tank and gas cylinder support.

Step 4: Install additional anchors

Additional anchors may be installed in the wall for extra support. See Anchors (page 96) or Masonry and Drywall Anchors (page 106).

Tanks and gas cylinders may be attached.

END OF ATTACHMENT.

Roof-mounted Attachment

The five ways to rigidly attach equipment to a roof are:

- Using leveling stanchions—also called post and beam (this page).
- To seismic built-up or seismic pre-manufactured curb (page 51).
- To a wood frame (page 57).
- Using a pre-manufactured seismic vibration isolation curb or leveling stanchions with equipment support frame (page 58).
- Using restrained springs on leveling stanchions (page 60).

Using leveling stanchions—post and beam

Step 1: Attach posts or stanchions

Bolt or weld stanchions to the building structure. To attach stanchions to different building structure types, see the detail in Figure 84 (page 49).

Support stanchions can be made from many different structural shapes.

Coordinate attachment points with the general contractor. Additional intermediate building structure beams may be required to accommodate the equipment.

The building structure must be capable of supporting the point load of the stanchions.

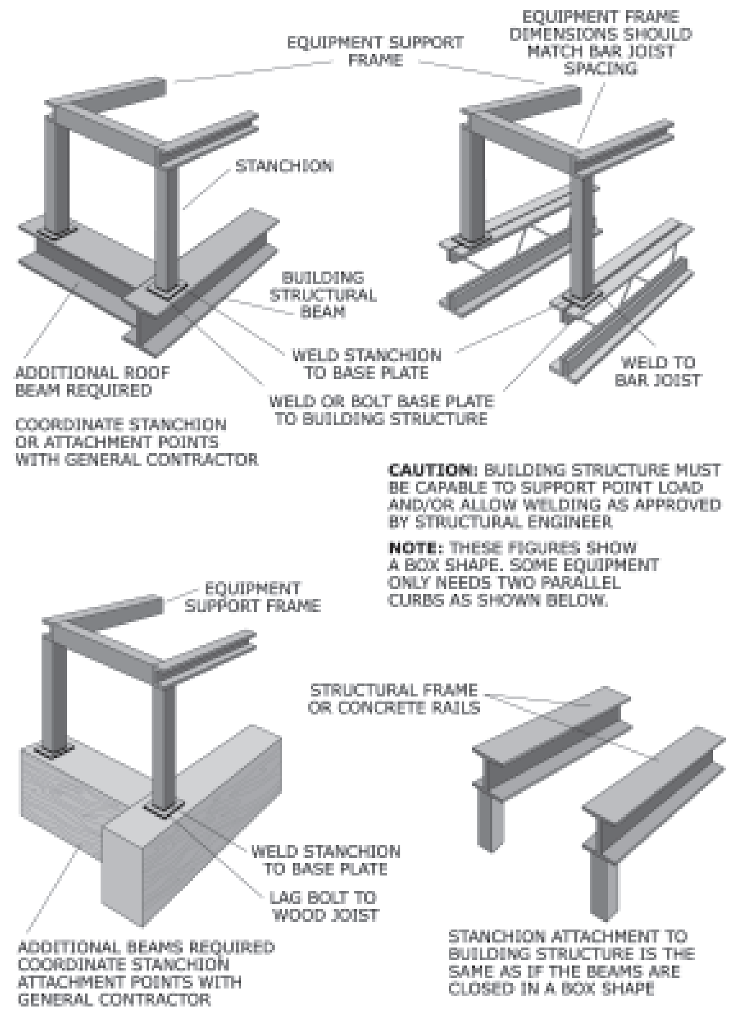


Figure 84: Attaching a stanchion to a building.

Step 2: Apply flashing to stanchions

Use standard details to flash around pipe stanchions or steel tubing. For flashing around a stanchion, which may not be uniform like an angle, channel, or I-beam steel shape, see Figure 85 (page 50).

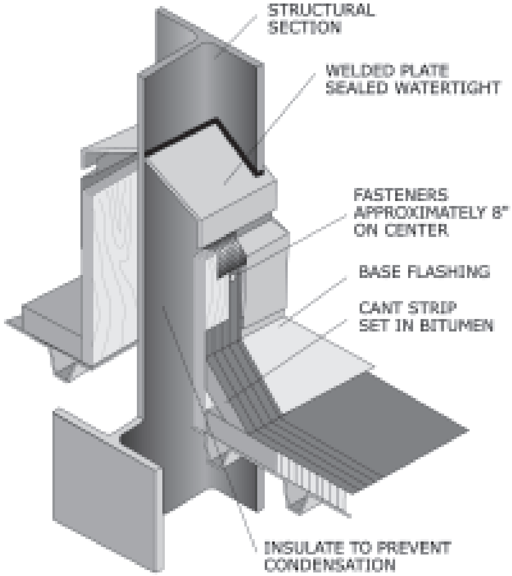


Figure 85: Flashing around a stanchion.

Step 3: Weld/bolt equipment support frame to stanchion

The equipment support frame may be box-shaped or have two parallel beams. The equipment support frame may be made from steel shapes such as angles, tubes, channels, or I-beams.

Step 4: Attach equipment

To rigidly attach the equipment to the equipment support frame, see Figure 86 (page 51).

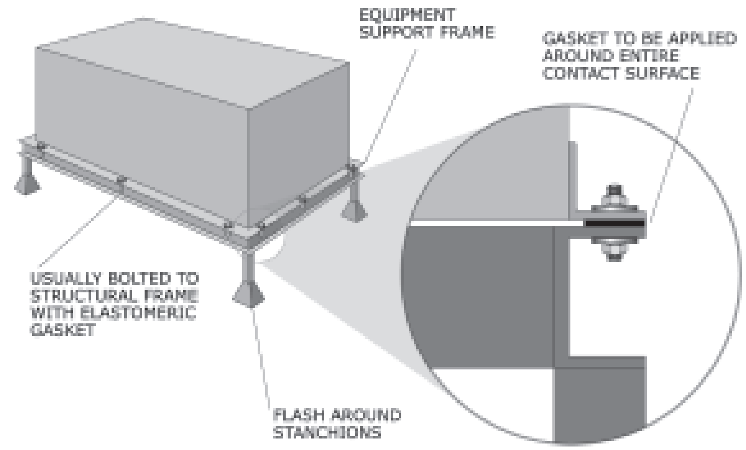


Figure 86: Rigid attachment of equipment to a support frame.

END OF ATTACHMENT.

To seismic built-up or seismic pre-manufactured curb

Step 1: Attach curb to roof or building structure

To attach the curb to the building structure, see Anchors (page 96).

To attach seismic-rated built-up curb to a roof structure, see Figure 87 (page 52) for one method of building a curb.

To attach seismic-rated pre-manufactured curb:

- Directly to the roof, see Figure 88 (page 53).
- To the building structure, see Figure 89 (page 54).

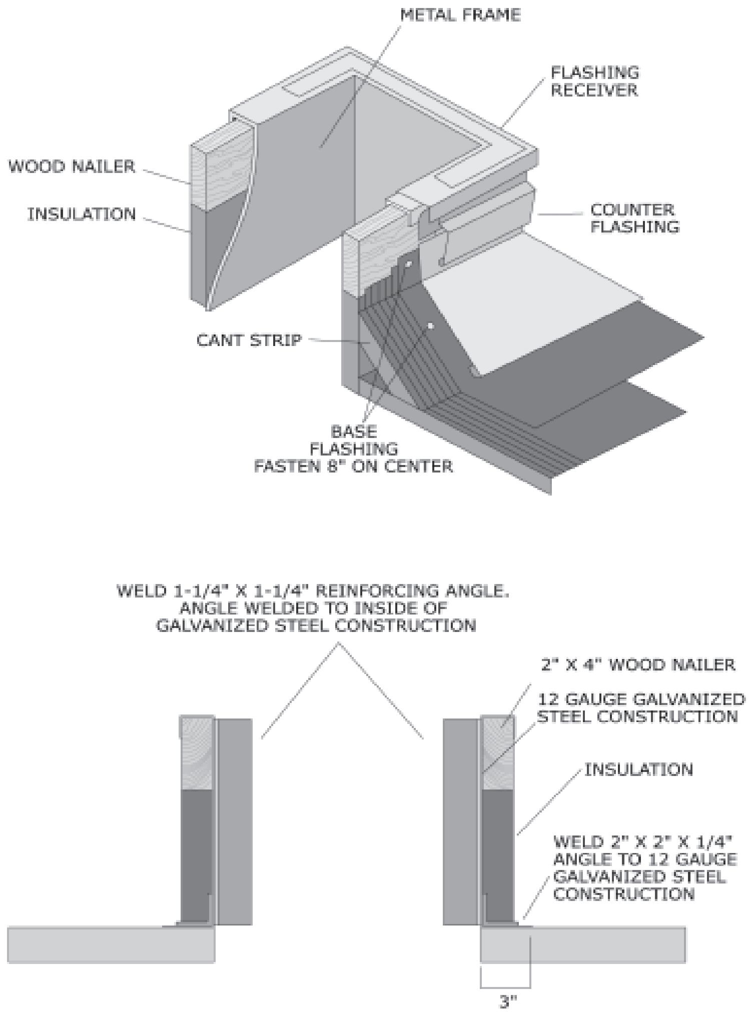


Figure 87: Seismic built-up curb details.

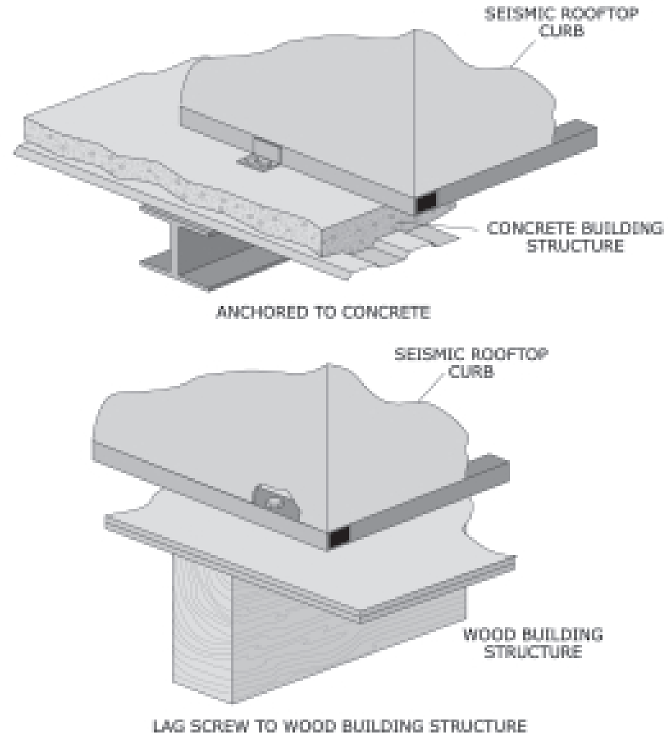


Figure 88: Pre-manufactured curb attached to a roof.

Follow the manufacturer's instructions for installing all seismic pre-manufactured curbs.

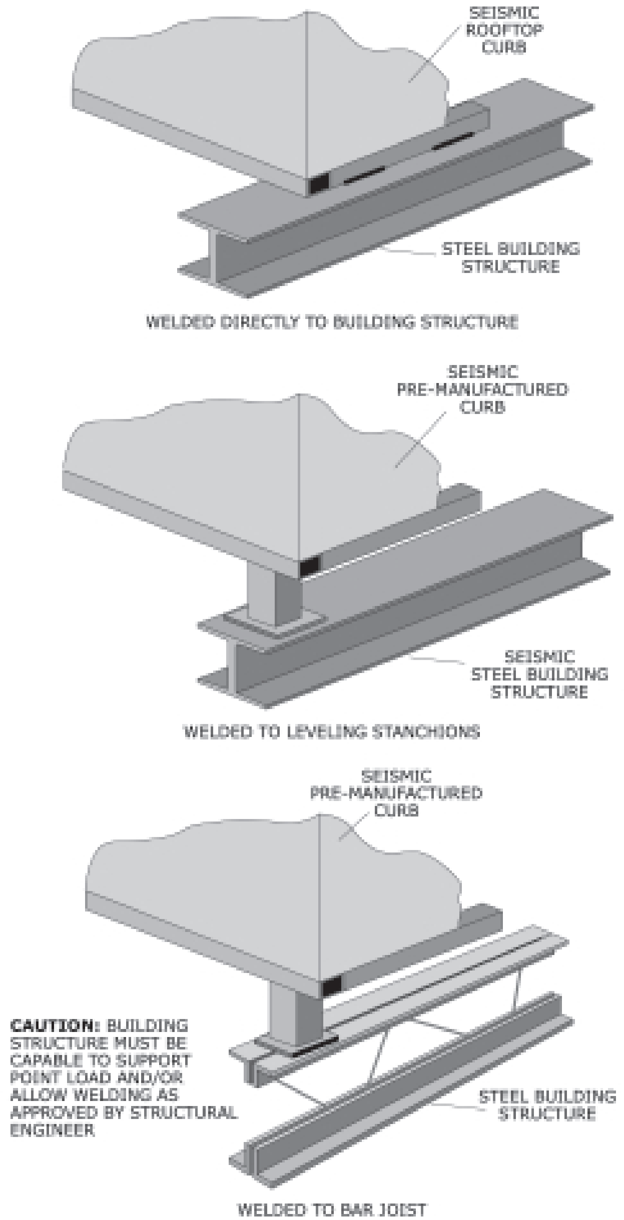


Figure 89: Pre-manufactured curb attached to the building structure.

Attachment: Roof-mounted

Step 2: Weld reinforcing angles

For built-up curb, weld reinforcing angles to the metal frame as shown in Figure 87 (page 52).

Step 3: Install flashing

Figure 87 shows the flashing for built-up curbs. This may be used for pre-manufactured curbs.

Step 4: Attach equipment

Attach the equipment to seismic built-up curb using lag wood screws/lag bolts as shown in Figure 90 (page 56). Space the lag wood screws or lag bolts according to the manufacturer’s instructions.

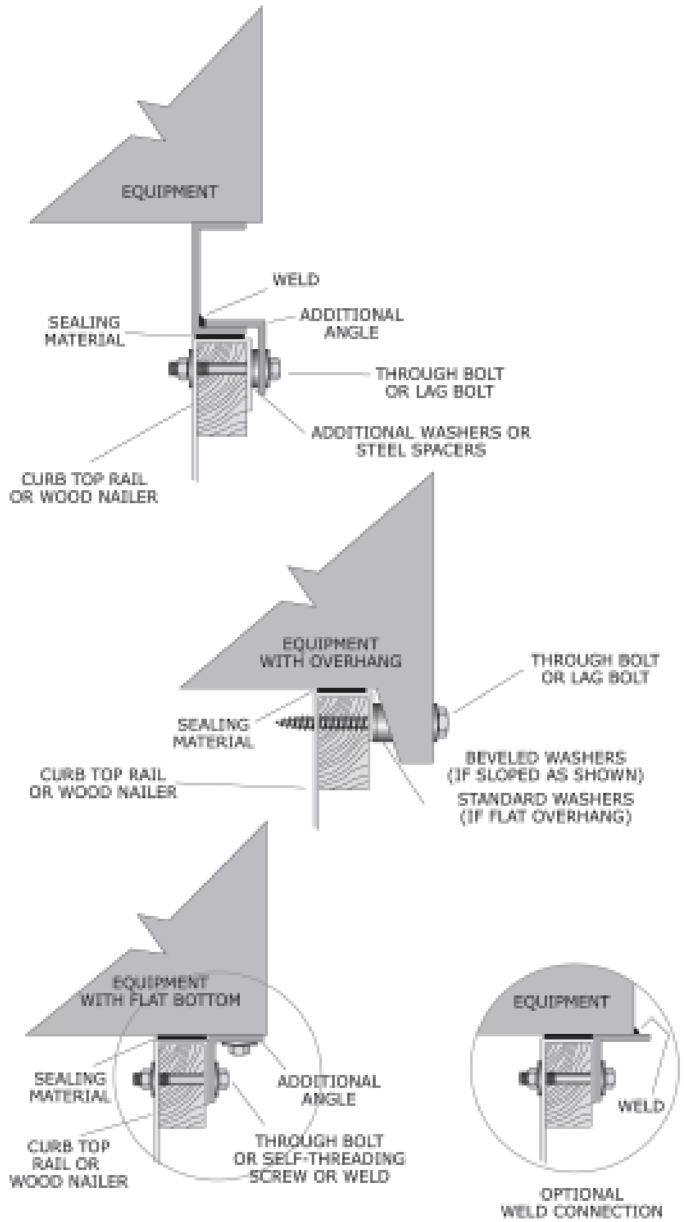


Figure 90: Attachment of equipment to a built-up curb or pre-manufactured curb.

END OF ATTACHMENT.

To a wood frame

Step 1: Attach wood frame to building structure

Figure 91 (below) shows a typical wood frame attachment.

Step 2: Install flashing

Figure 91 (below) shows typical flashing.

Use contract documents for flashing details.

Step 3: Attach equipment to the wood frame

Attach equipment directly to the wood frame as shown below. Wood frames can restrain equipment with internal frames or with support legs as shown.

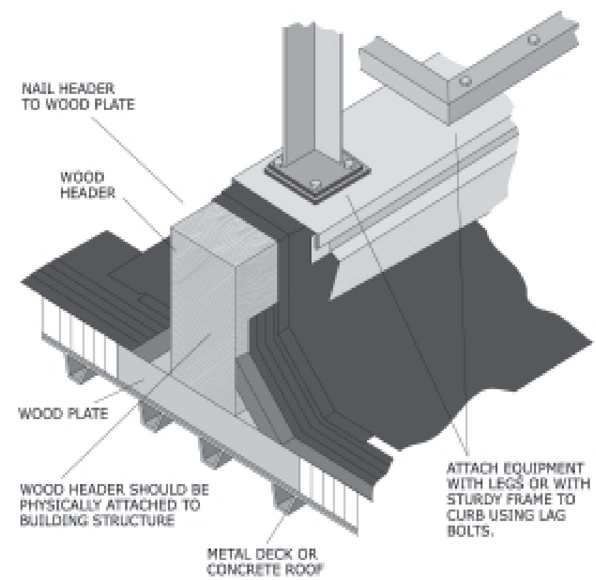


Figure 91: Attachment of equipment to a wood frame.

END OF ATTACHMENT.

Using a seismic pre-manufactured vibration isolation curb

Figure 92 (below and next page) shows the vibration isolation curb attached to a rigid base. The base may be a rigid curb as shown in Figure 92 or a post and beam frame (see Figure 84, page 49).

Step 1: Attach curb or post and beam with equipment support frame to building structure

If a rigid curb is the base of the vibration isolation curb, go to page 51 and follow instructions for rigidly attaching equipment to a built-up or pre-manufactured curb.

If a post and beam is the base of the vibration isolation curb, go to page 48 and follow instructions for rigidly attaching equipment with leveling stanchions.

Step 2: Install flashing

Install flashing for a rigid curb as shown in Figure 87 (page 52) or flash the stanchions as shown in Figure 85 (page 50).

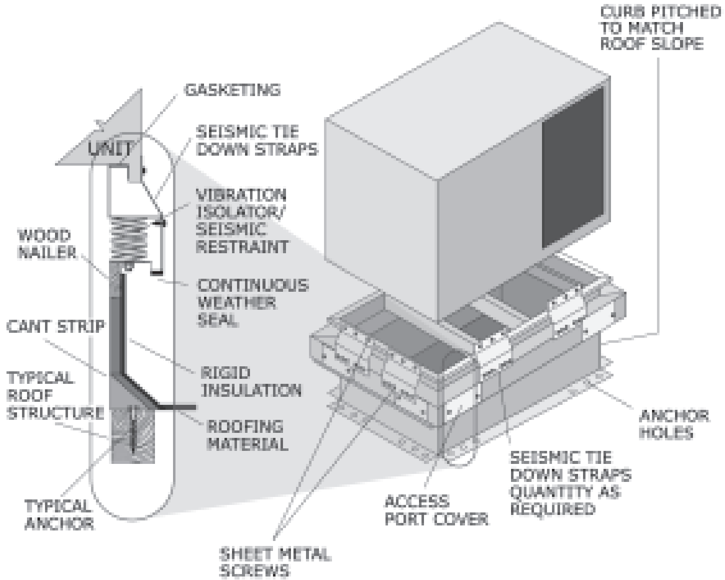


Figure 92: Various types of manufactured isolator systems (continued on next page).

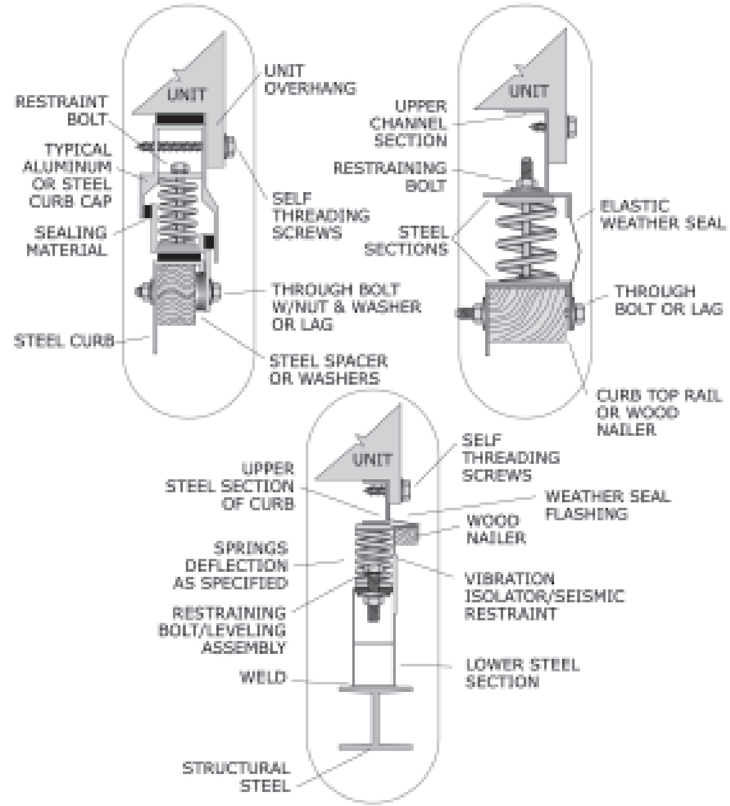


Figure 92: Various types of manufactured isolator systems.

Step 3: Attach vibration isolation curb to base

Figure 92 (page 58 and above on this page) shows through-bolts or lag screws used to attach curb to base.

Use contract documents for flashing details.

Step 4: Attach equipment to the vibration isolation curb and level

Figure 92 (page 58 and above on this page) shows various seismic attachment methods used to attach equipment to a vibration isolation curb and level.

END OF ATTACHMENT.

Using restrained springs on leveling stanchions

Figure 93 (below) shows a typical installation of restrained spring vibration isolated equipment on stanchions and an equipment support frame.

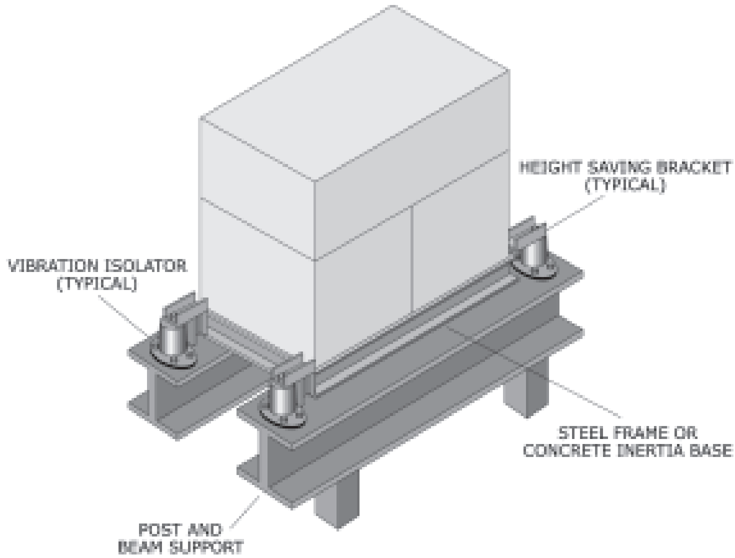


Figure 93: Equipment attached using restrained springs on a post and beam.

More than four restrained springs may be required. See the manufacturer's instructions.

Verify that the spring is properly aligned according to the manufacturer's recommended clearances. If the spring shaft rubs against the snubber element, a short-circuit may occur, causing noise problems.

Step 1: Attach posts or stanchions

Bolt or weld stanchions to the building structure. Refer to the detail in Figure 84 (page 49) for attaching stanchions to different building structure types. Support stanchions can be made from many different structural shapes.

Coordinate attachment points with the general contractor. Additional intermediate building structure beams may be required to accommodate the equipment.

THE BUILDING STRUCTURE MUST BE CAPABLE OF SUPPORTING THE POINT LOAD OF THE STANCHIONS.

Step 2: Apply flashing to stanchions

Use standard details to flash around pipe stanchions or steel tubing. For flashing around a stanchion, which may not be uniform like an angle, channel, or I-beam steel shape, refer to Figure 85 (page 50).

Step 3: Weld/bolt equipment support frame to stanchions

The equipment support frame may be box-shaped or have two parallel beams. The equipment support frame may be made from steel shapes such as angles, tubes, channels, or I-beams.

Step 4: Attach restrained springs

Attach restrained springs to the curb using steel bolts.

The support frame must be wider than the base plate of the restrained spring.

Step 5: Install equipment on springs

Install equipment on springs with attachment nuts and level.

Bases are required for mounting equipment with restrained springs. Do not use restrained springs on a built-up curb.

END OF ATTACHMENT.

Suspended Attachment

The four ways to suspend equipment are by:

- Rigid connection to the building structure using four threaded vertical rods with horizontal cable supports (this page).
- Rigid connection to the building structure using angle/ strut supports (page 68).
- Isolated connection to the building structure using four threaded vertical rods and horizontal cable supports (page 70).
- Double angle attachment–bolted or welded to the building (page 73).
- Double rod attachment–bolted to the building (page 75).

Rigid connection to the building structure using four threaded vertical rods with horizontal cable supports

Equipment should have pre-installed brackets that can support the attachment to the building.

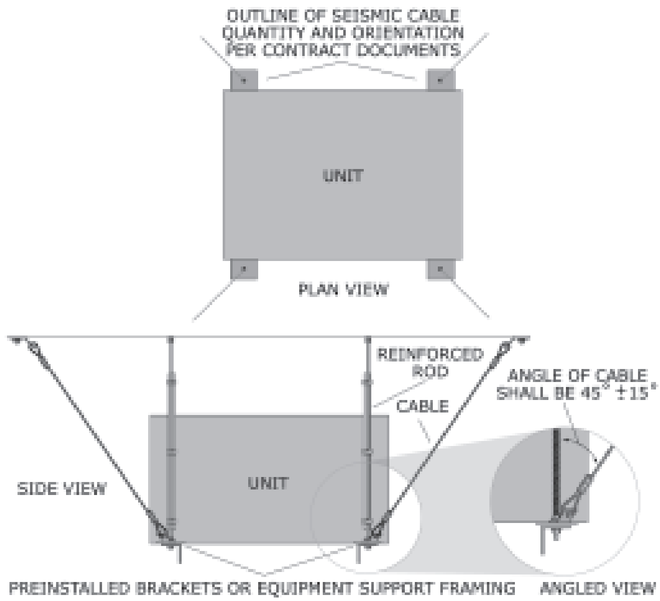


Figure 94: Rigid connection to the building structure.

Cables provide horizontal support for seismic loads and should not be installed to hang equipment.

Step 1: Attach the equipment to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 95 to 100 (below and pages 64-65). For instructions on bolting directly to the building structure, see Steel Bolt Connections (page 114).

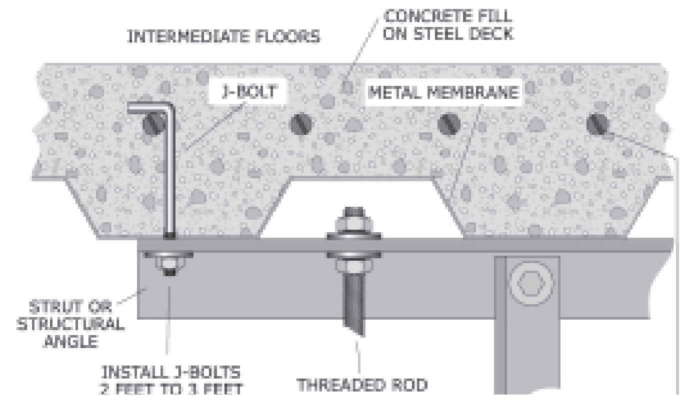


Figure 95: Cast-in-place anchor; concrete fill on steel deck.

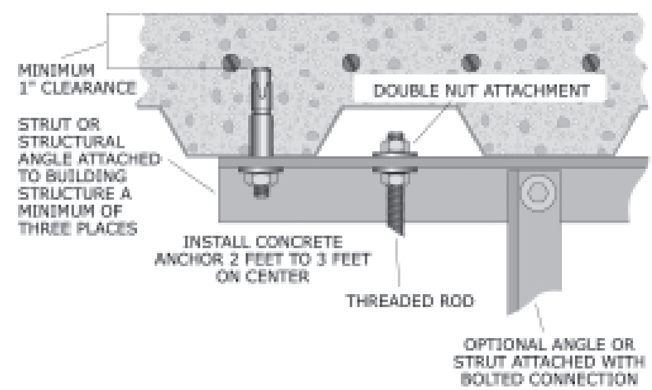


Figure 96: Post-installed anchor; concrete fill on steel deck.

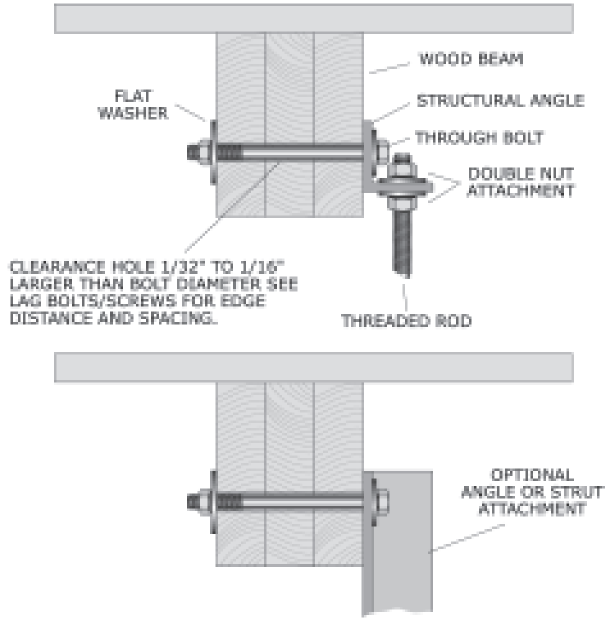


Figure 97: Wood beam construction.

For edge distances and spacing, see Lag Bolts (page 104).

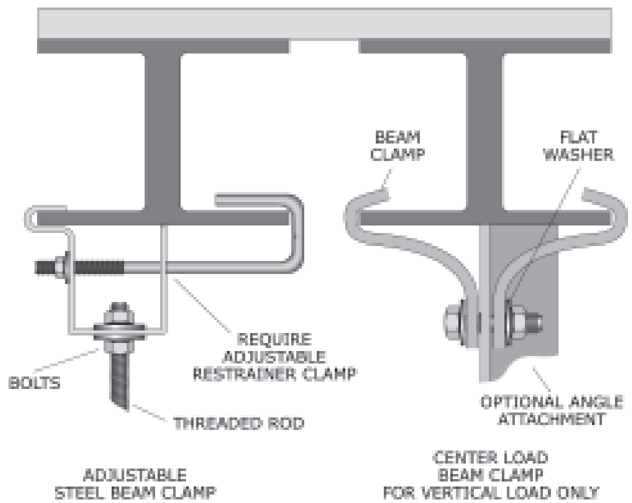


Figure 98: Steel beam construction.

Use center load beam clamps for vertical loads. Do not use for cables, rods, or structural members positioned at an angle.

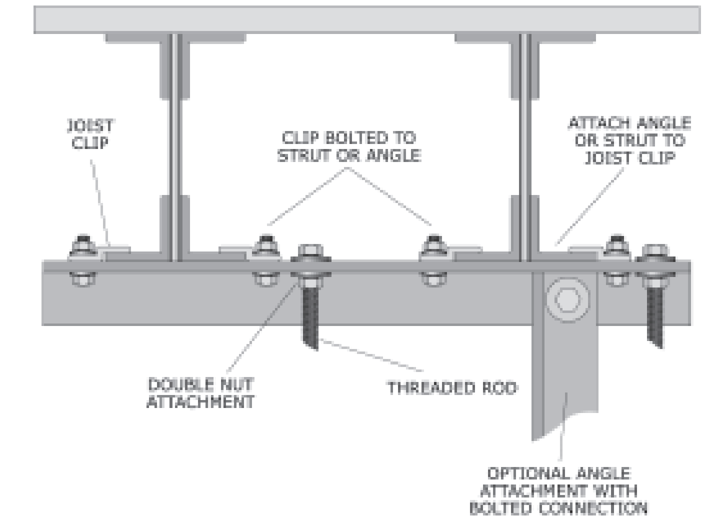


Figure 99: Bar joist construction.

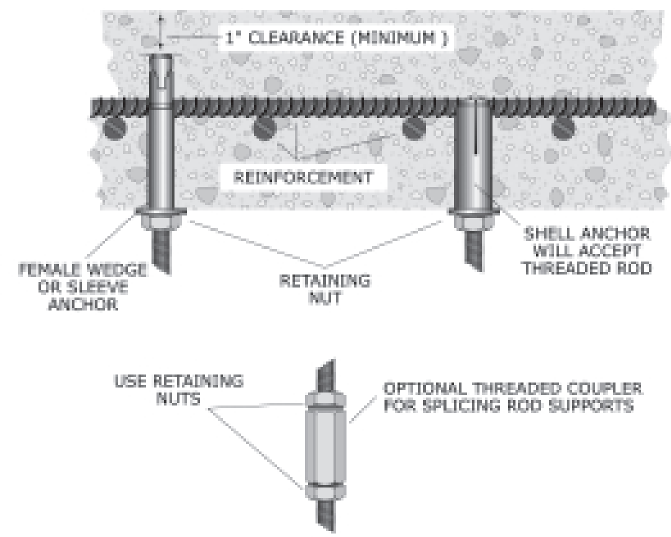


Figure 100: Concrete slab construction.

Step 2: Add rod stiffeners

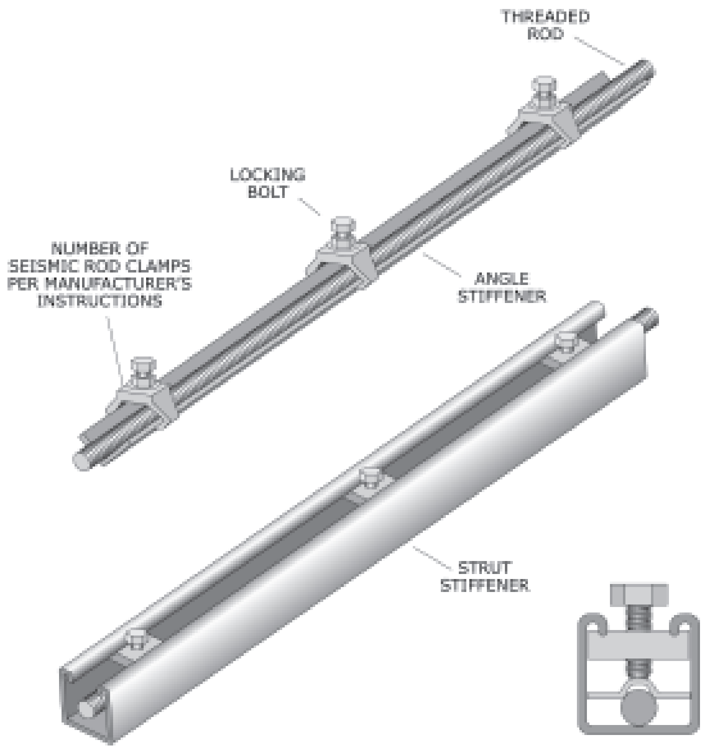


Figure 101: Rod stiffeners.

Step 3: Attach anchors to the building structure for cable attachment

Figure 102 (page 67) shows typical anchorage to different building construction. See Anchors, page 96.

Step 4: Attach cable to the building structure

For cable assembly instructions, see Cables (page 124).

For details on attaching cable to the building structure, see Figure 102 (page 67).

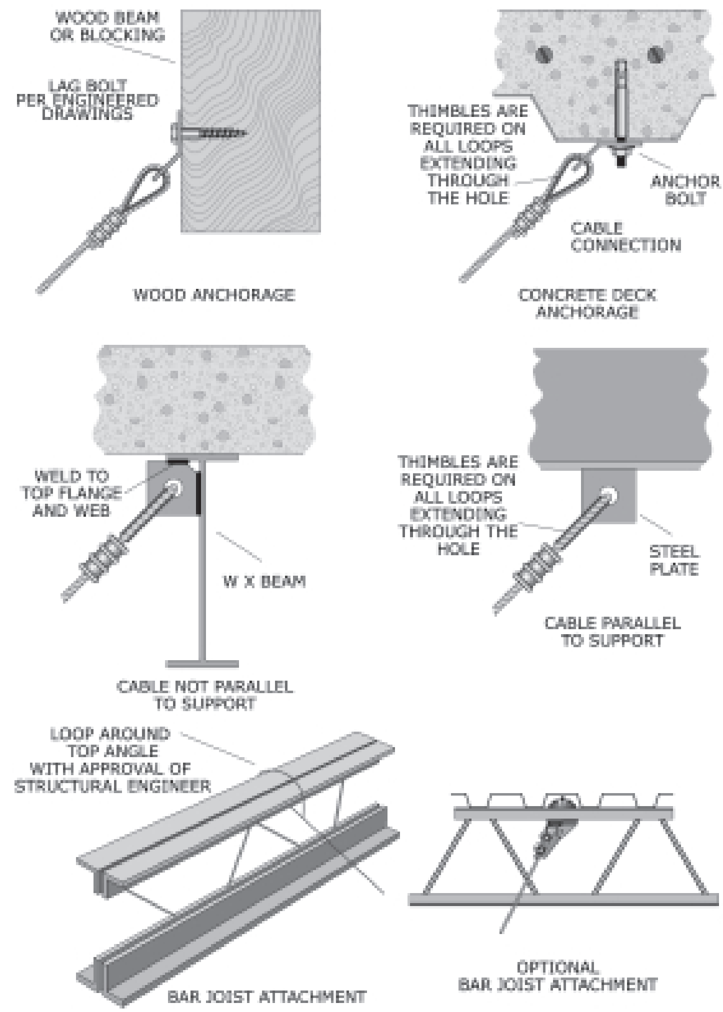


Figure 102: Attachment of cable to the building structure.

Step 5: Attach cables to equipment

For details on attaching cable to the equipment, see Figure 103 (page 68).

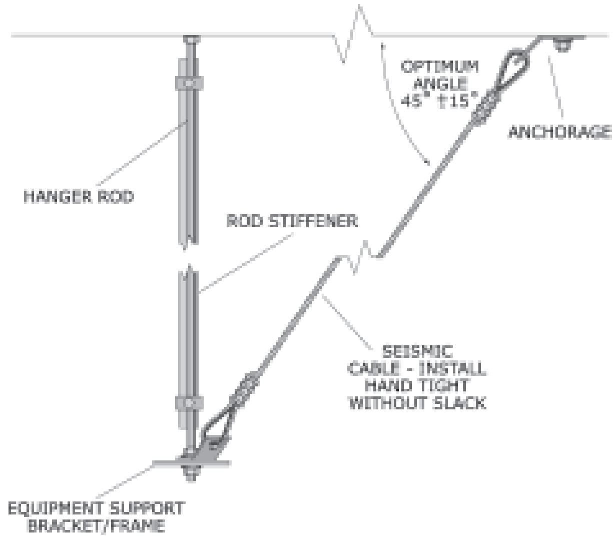


Figure 103: Attachment of cable to the equipment.

END OF ATTACHMENT.

Rigid connection to the building structure using angle/ strut supports

Equipment may have pre-installed brackets for angle support attachments as shown below in Figure 104.

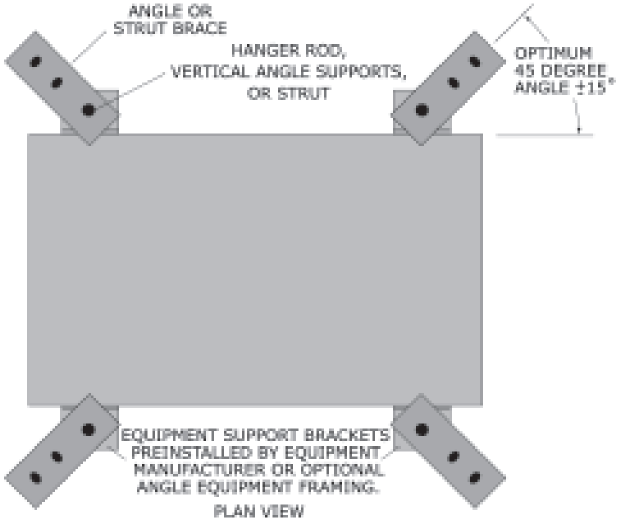


Figure 104: Rigid attachment of angles to the building structure.

Step 1: Attach the equipment to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 95 to 100 (pages 63-65). See Anchors (page 96). Rod stiffeners are not required.

Step 2: Attach anchors to the building structure for angle or strut supports

For building structure attachment details, see Figures 95 to 100 (pages 63-65). See Anchors (page 96).

Step 3: Attach angles or strut supports to the building structure

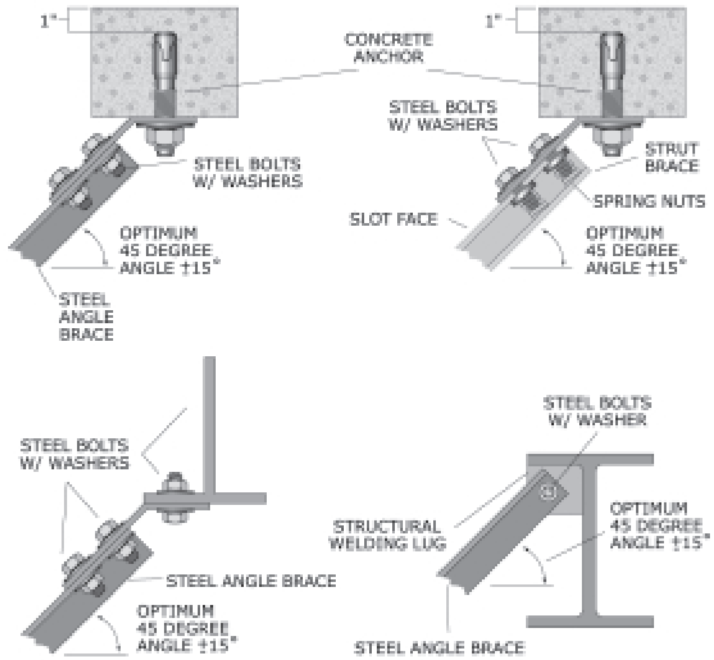


Figure 105: Attachment of angle or strut to the building structure.

Step 4: Attach angle or strut to equipment

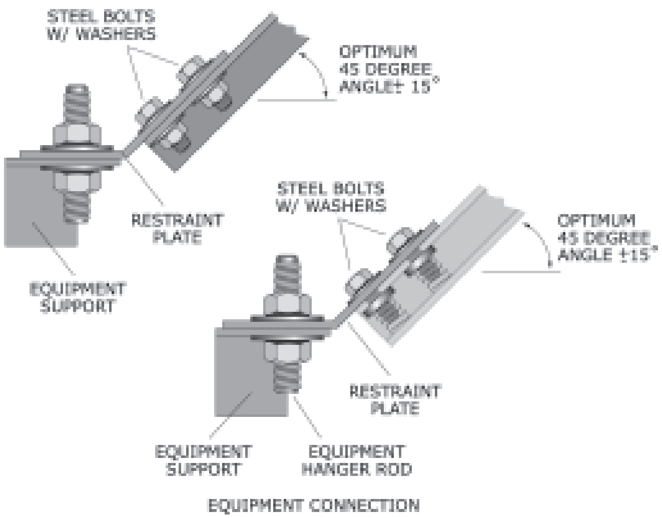


Figure 106: Attachment of angle or strut to the equipment.

END OF ATTACHMENT.

Isolated connection to the building structure using four threaded vertical rods and horizontal cable restraints

Equipment may have pre-installed brackets for angle support attachments. See Figure 107 (below) and Figure 108 (page 71).

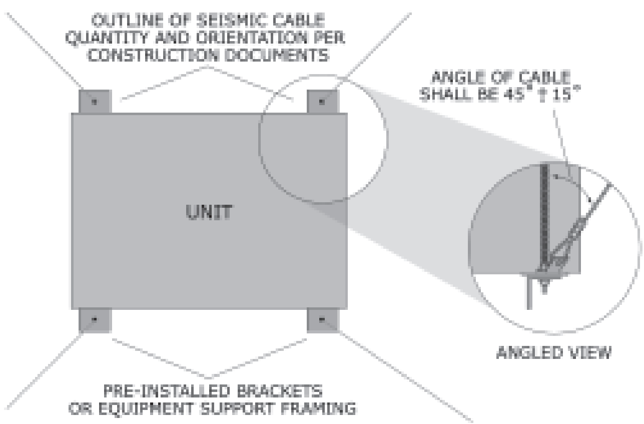


Figure 107: Plan view of vibration isolation suspended attachment to the building structure.

Side view shows vibration isolators, rods (without rod stiffeners), and cables.

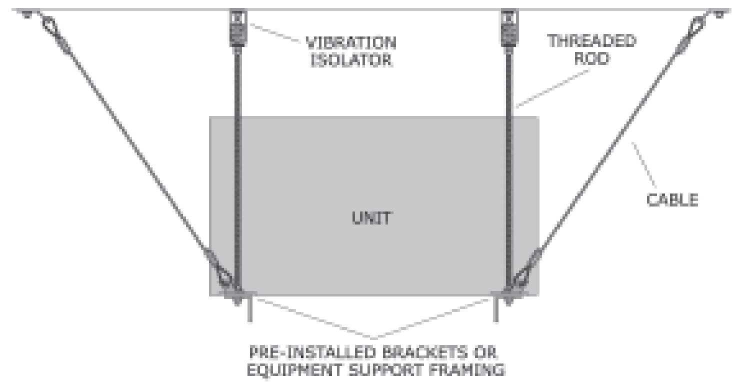


Figure 108: Side view of vibration isolation suspended attachment to the building structure.

Step 1: Attach equipment to the building structure using threaded rods, isolators and anchors

For the isolator detail, see Figure 109 (below). For building structure attachment details, see Figures 95 to 100 (pages 63-65).

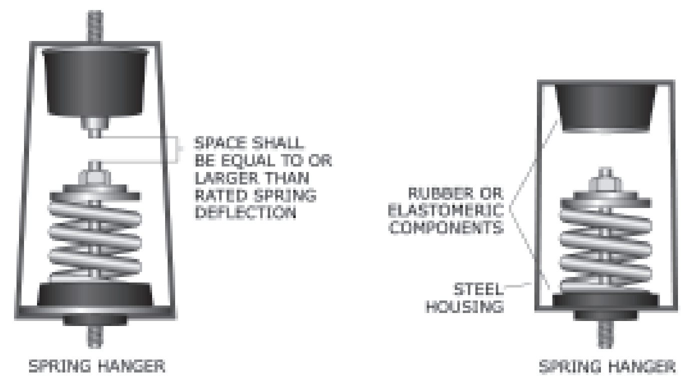


Figure 109: Isolator detail.

Step 2: Attach anchors and cable to the building structure

For details on anchorage and cable connection to the building structure, see Figure 102 (page 67).

Step 3: Attach cables to equipment

For cable assembly, see Cables (page 124). For cable attachment to equipment, see Figure 110 (below).

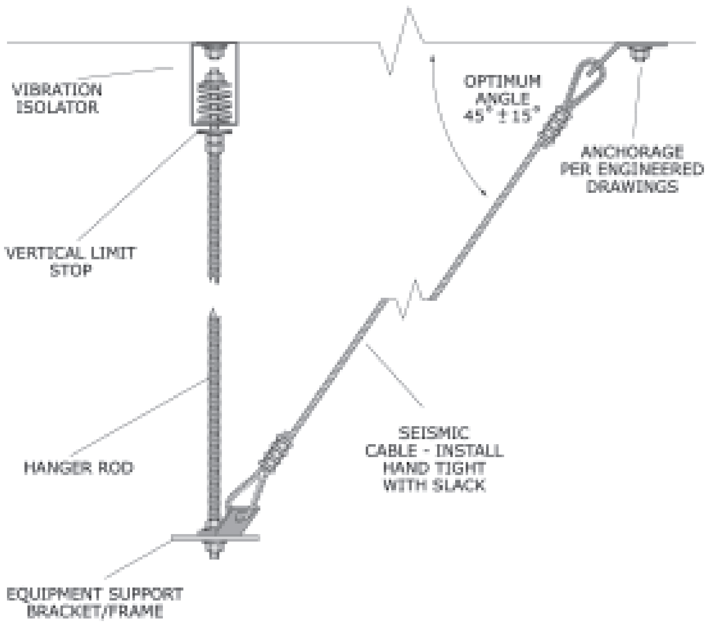


Figure 110: Attachment of cable/rod assembly to the equipment.

END OF ATTACHMENT.

Double angle attachment—bolted or welded to the building

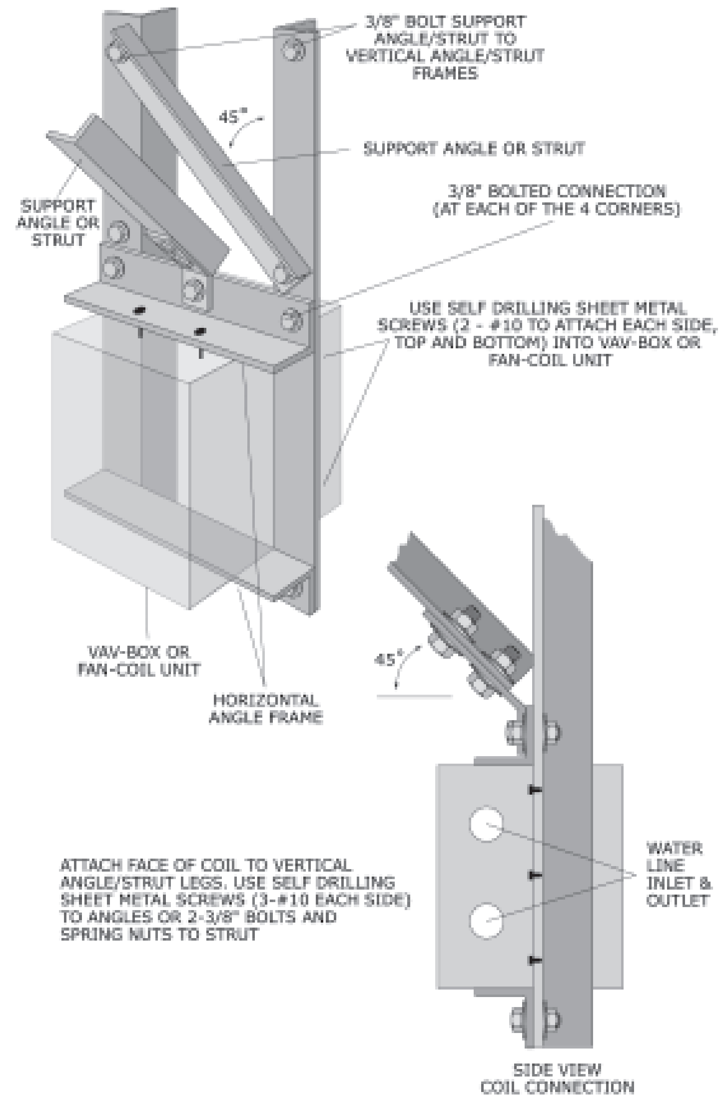


Figure 111: Attachment of double angles for equipment support.

Use this type of installation for duct-mounted coils, VAV boxes, or fan-coil units weighing less than 150 pounds.

Step 1: Attach anchors and vertical angles or strut to the building structure

For building structure attachment details, see Figures 95 to 100 (pages 63-65).

Step 2: Attach horizontal framing

For attachment details, see Figure 111 (page 73).

Step 3: Attach anchors to the building structure for angle or strut restraints

For building structure attachment details, see Figure 105 (page 69). See Anchors (page 96).

Step 4: Attach support angles or struts

One support is attached to the two vertical angles or struts. One support is attached to the building structure and to the top horizontal frame. For details on angle or strut attachment, see Figure 111 (page 73).

Step 5: Attach equipment

Attach equipment to the support assembly as shown in Figure 111 (page 73).

END OF ATTACHMENT.

Double rod attachment—bolted to the building

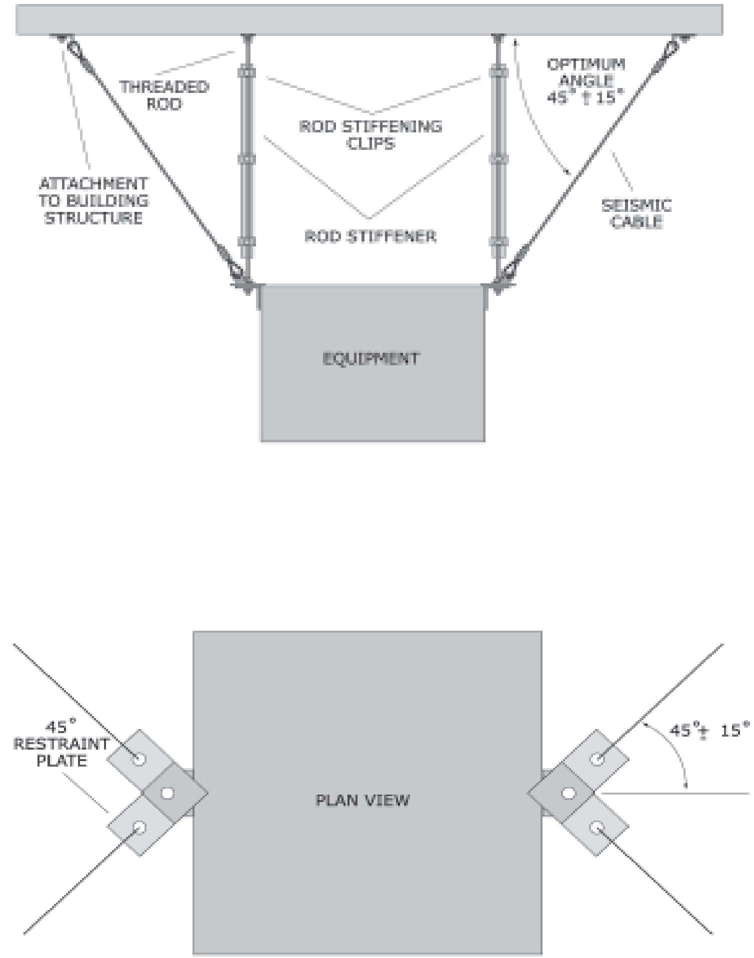


Figure 112: Equipment attachment for double rod support.

Use this type of installation for unit heaters.

Step 1: Attach anchors and vertical rods to the building structure

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 95 to 100 (pages 63-65). Attach equipment to the vertical rods.

The attachment should be located just above the center of gravity to minimize swinging. It should be a rigid attachment with brackets to the equipment using double nuts, especially if connected at the top as shown in Figure 112 (page 75).

Step 2: Attach rod stiffeners

For attachment details, refer to Figure 101 (page 66).

Step 3: Attach anchors to the building structure for cable attachment

Figure 102 (page 67) shows typical anchorage to different building construction. See Anchors (page 96).

Step 4: Attach cable to the building structure

For cable assembly see Cables (page 124).

For details on attaching cable to the building structure, see Figure 102 (page 67).

Step 5: Attach cables to equipment

The detail in Figure 112 (page 75) shows the attachment to the equipment.

Vibration-isolated/Floor-mounted Attachment

Vibration isolation uses springs in many different shapes to isolate equipment vibrations from the building structure. Their shapes are open (see Figure 113 below left), housed (see Figure 113 below right), and restrained (see Figure 114, page 78).

NEVER USE HOUSED SPRINGS FOR SEISMIC RESTRAINT APPLICATIONS. Housed springs cannot resist uplift.

Snubbers (see Figure 115, page 78) are restraint devices to limit the movement of equipment that is isolated. Bumpers (see Figure 116, page 79) also limit the movement of equipment and are similar to snubbers.

NEVER USE SNUBBERS THAT ARE NOT SPECIFIED. Some snubbers only restrict movement in one direction.

NEVER USE OPEN SPRINGS WITHOUT SNUBBERS OR BUMPERS. Equipment mounted on open springs without snubbers or bumpers will fail.

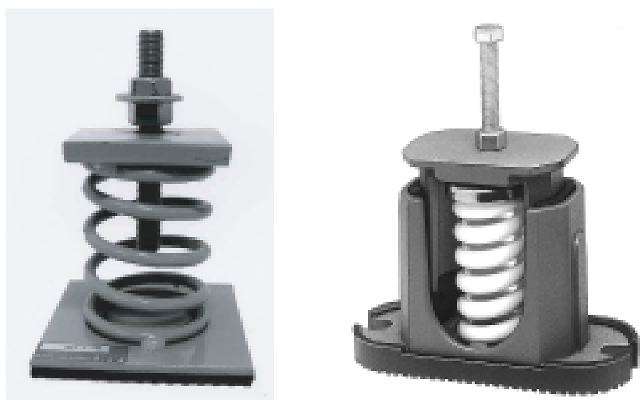


Figure 113: Open spring and housed spring.

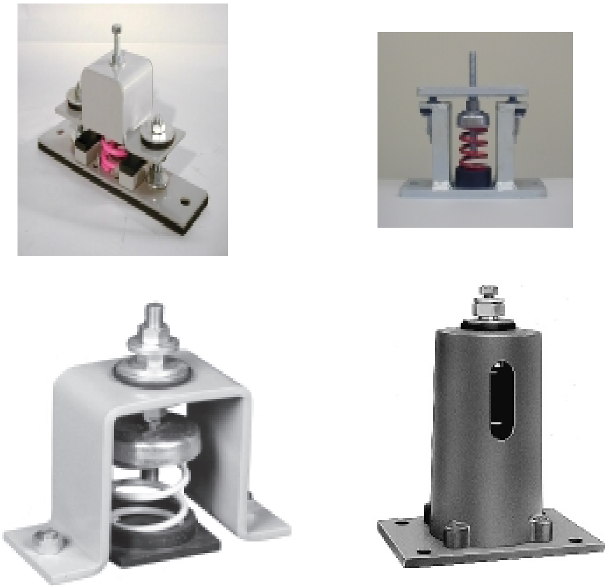


Figure 114: Four types of restrained springs.

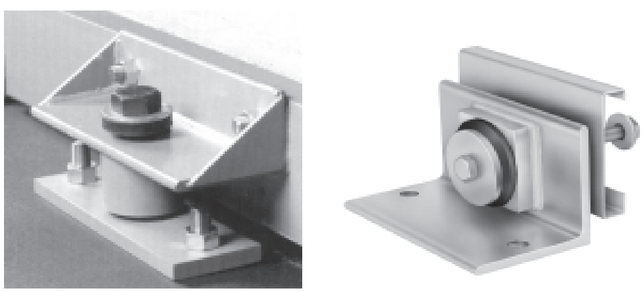


Figure 115: Two examples of snubbers.

Verify that the spring is properly aligned according to the manufacturer's clearances. If the spring shaft rubs against the snubber element, a short-circuit may occur, causing noise problems.

Attachment: Vibration-isolated/Floor-mounted

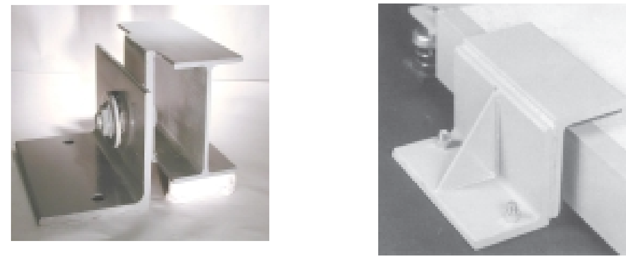


Figure 116: Two examples of bumpers.

Bases are steel structures made from angles, channels, or I-beams.

Bases are required for mounting isolated equipment. The equipment manufacturer or the isolator manufacturer may provide the bases.

The two ways of attaching vibration-isolated/floor-mounted equipment are on:

- Restrained springs (this page).
- Open springs combined with snubbers (page 83).

Restrained springs

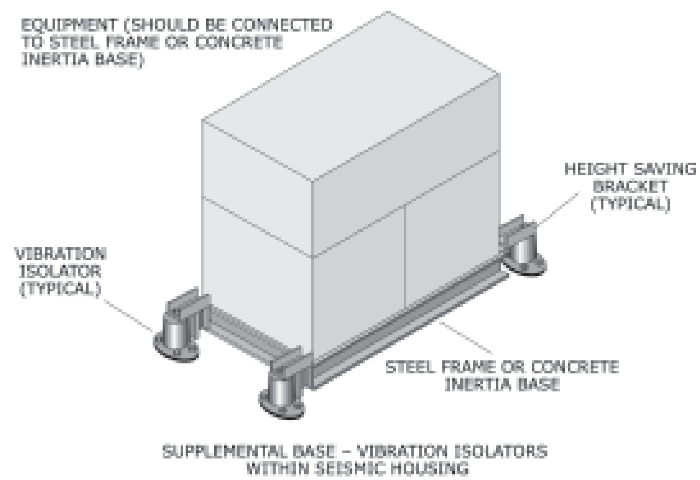


Figure 117: Typical installation of restrained spring installation.

More than four restrained springs may be required. See the manufacturer's instructions.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor or pad using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.

Step 2: Install anchors

Drill and install post-installed anchors or pour concrete with embedded studs or J-bolts (see Anchors, page 96).

Step 3: Set restrained spring isolators and bolt to anchors

Install restrained springs to the building structure as shown in Figure 118 (page 81). Attach nuts to the anchor. Use bolts for shell-type anchors or internally threaded wedge or chemical anchors. Torque as recommended by the anchor manufacturer.

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT OR ISOLATOR.

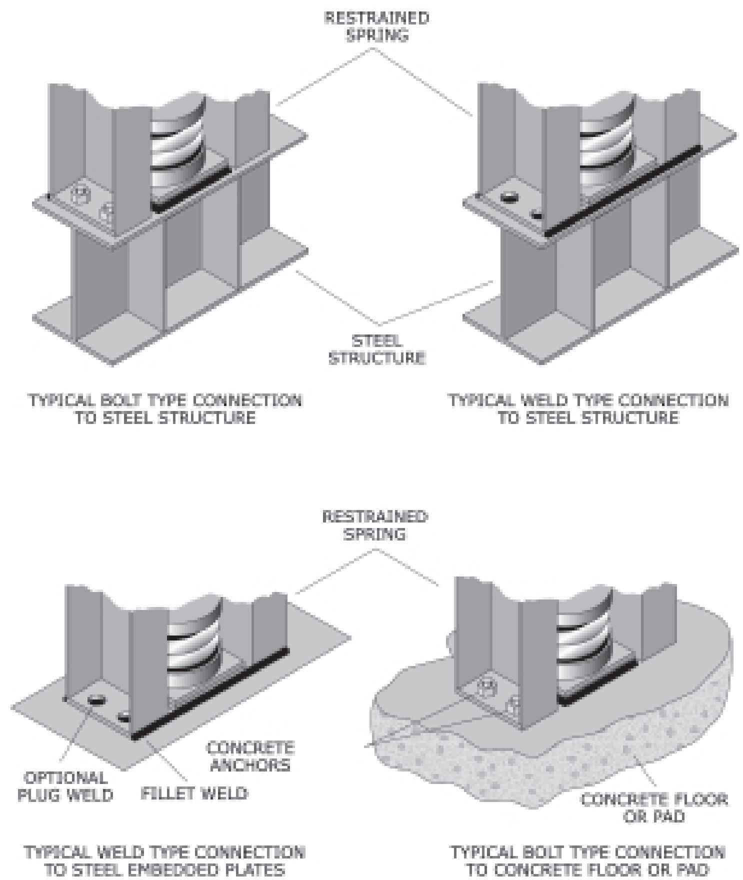


Figure 118: Attachment of restrained springs to the bulding structure.

Step 4: Move the equipment into place over the isolators

Use leveling nuts to level the equipment. Use attachment nuts to attach the base of the equipment to the isolator.

Figure 119 (page 82) shows typical ways to connect the equipment to the restraints.

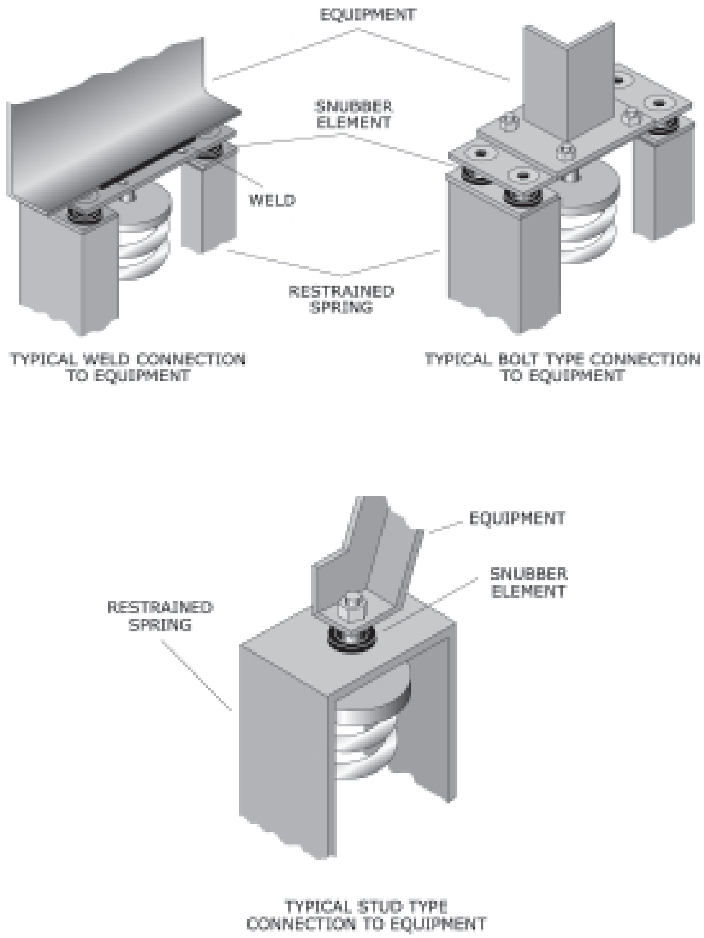


Figure 119: Attachment of equipment to restrained springs.

END OF ATTACHMENT.

Open springs combined with snubbers

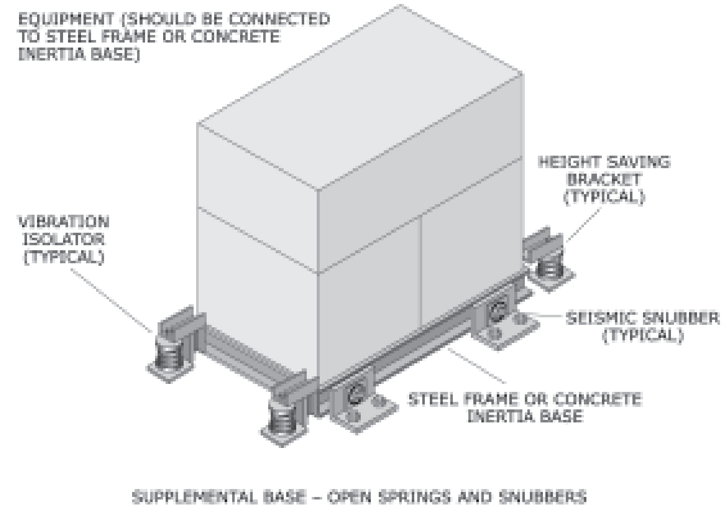


Figure 120: Typical installation of open springs and snubbers.

Additional snubbers may be required. See the manufacturer's instructions.

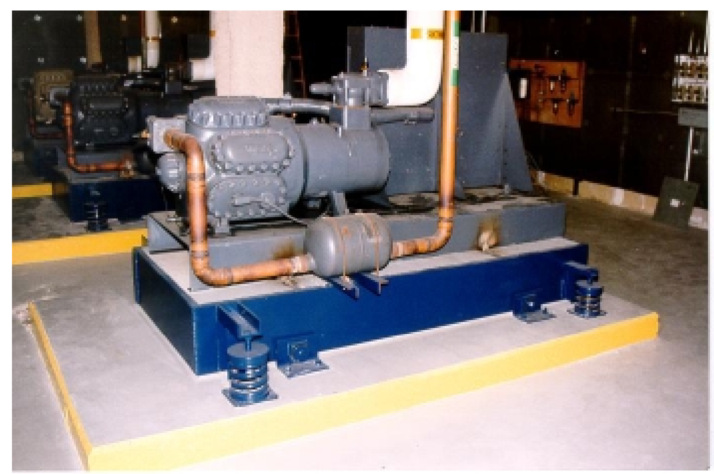


Figure 121: Typical installation of an open spring arrangement with snubbers.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern for the open spring mounting plate on the floor or pad using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and shop drawings to lay out the bolt hole pattern.

Step 2: Install post-installed anchors for open springs only (snubbers are covered in later steps)

Drill and install post-installed anchors for spring isolators (see Anchors, page 96).

Step 3: Attach open spring isolators to concrete floor or pad with anchors installed in Step 2

Set isolator, apply nuts and torque. Use bolts for shell-type anchors or internally threaded wedge or chemical anchors. Install according to the anchor manufacturer's instructions.

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE ISOLATOR.

Step 4: Set equipment on open springs

Set equipment on isolators but do not level or torque attachment nuts.

Equipment must have a structural frame capable for point load at the open spring isolators.

Some installations require the base to be concrete-filled. See Figure 122 (page 85) for a typical concrete-filled installation.

Coordinate the location of equipment attachment points and snubber attachment points before filling with concrete.

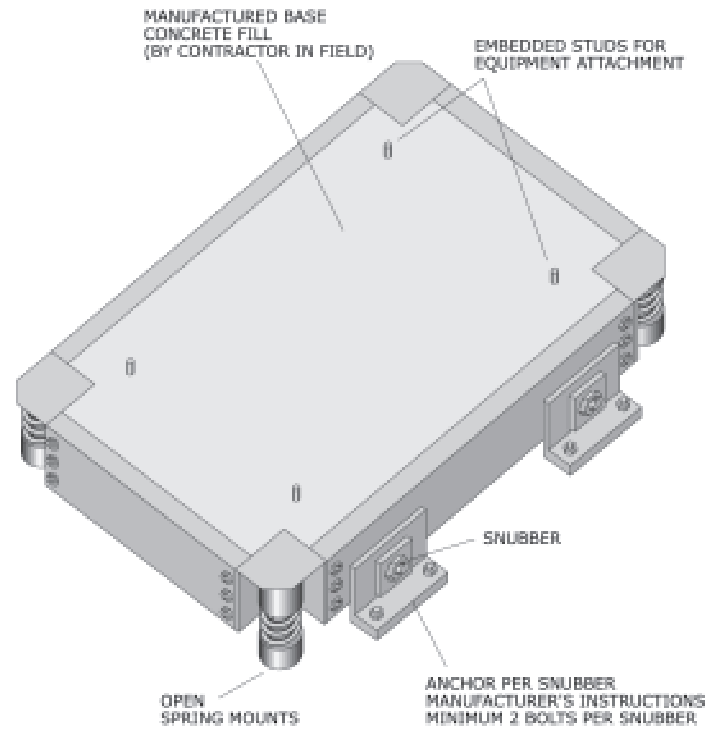


Figure 122: Concrete-filled inertia base.

Step 5: Determine where to attach snubber

A snubber has two assemblies: the snubber equipment assembly and the snubber base assembly.

Level the equipment. Final leveling will be required in later steps. Accurately draw the bolt pattern for the snubber mounting plate on the floor or pad and on the equipment.

All snubber clearance requirements for aligning the snubber must be met. Shims may be provided.

Step 6: Attach snubber equipment assembly to equipment

Attach the snubber equipment assembly to the equipment by bolting it to embedded bolts in a concrete-filled base (see Figure 122, page 85), or by bolting or welding it to a steel base.

Step 7: Determine where to bolt snubber base

Accurately draw the bolt pattern for the snubber mounting plate on the floor or pad.

Step 8: Drill and install post-installed anchors

See Anchors (page 96).

Step 9: Raise the equipment

Raising the equipment allows the snubber base assembly to be placed over the anchors installed in Step 6.

Step 10: Lower the equipment

Level equipment and connect the two snubber assemblies as specified in the manufacturer's instructions. Verify that spacing requirements are met. Complete the final attachment to open springs.

DO NOT INSTALL THE ISOLATOR OR SNUBBERS IN ANY CONFIGURATION OTHER THAN THAT SHOWN IN THE MANUFACTURER'S INSTRUCTIONS.

The equipment is now installed to resist earthquakes. Flexible piping connections, flexible ductwork connections, and flexible conduit connections must be used when connecting systems to isolated equipment.

Figure 123 (page 87) is an example of the requirements for flexible system connections.

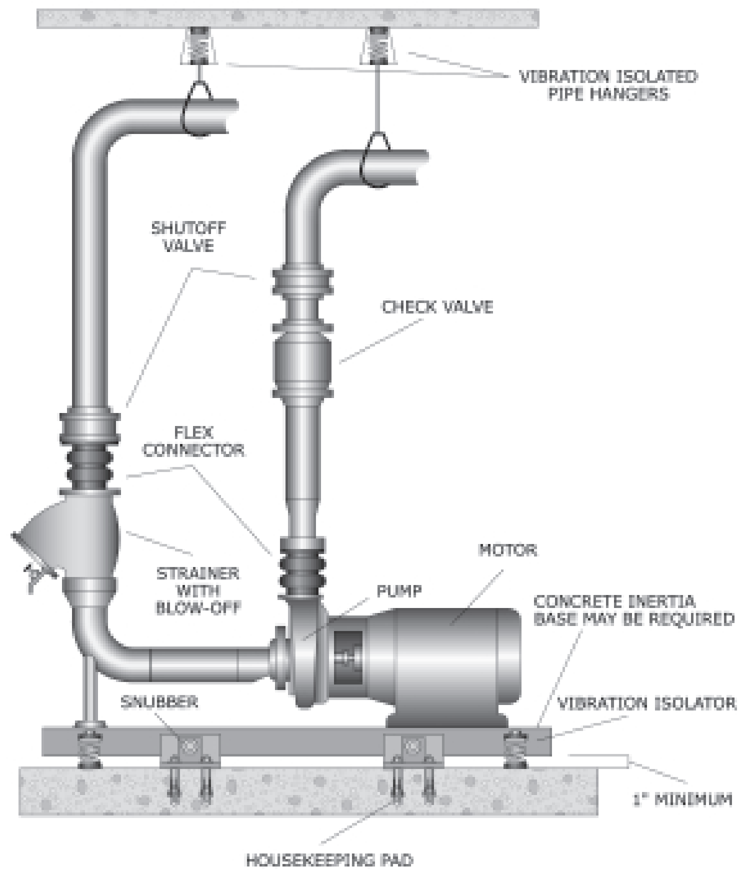


Figure 123: Typical pump installation.

END OF ATTACHMENT.

Wall-mounted Attachment

The four types of wall mounting are:

- Directly to the wall (this page).
- To additional structural steel shapes attached to the wall (page 90).
- Vibration-isolated off the wall (page 93).
- Directly to the wall—gas cylinders only (page 95).

Directly to the wall

Equipment should have pre-installed brackets that can support attachment to the building as shown in Figure 124 (below).

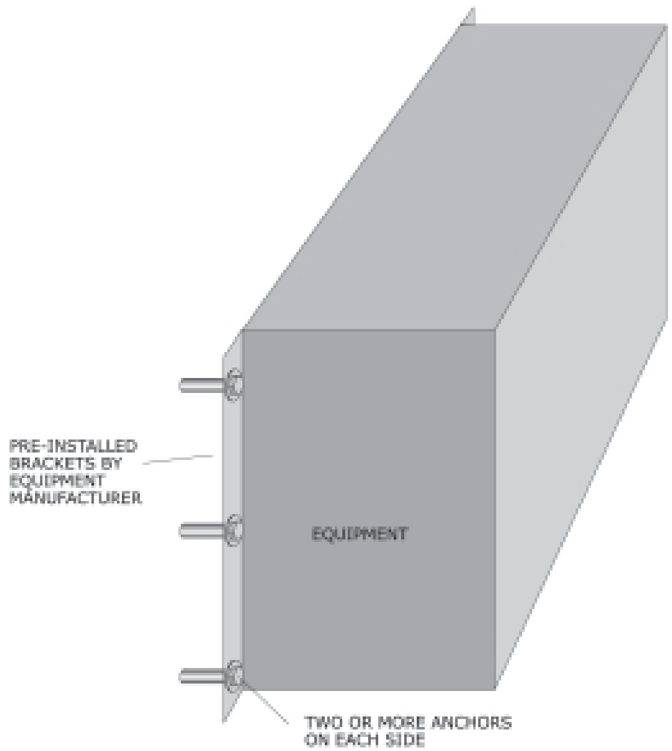


Figure 124: Direct attachment to a wall.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the wall using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

Drywall or masonry walls may require additional holes in equipment attachment brackets as shown on construction drawings or in the equipment manufacturer's instructions.

ONLY USE MOUNTING BRACKETS PROVIDED. DO NOT DRILL INTO THE EQUIPMENT HOUSING.

New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 71 (page 35).

Step 2: Install post-installed anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 96, or Masonry and Drywall Anchors, page 106).

Step 3: Move the equipment into place

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.

Step 4: Attach nuts

Attach nuts to the anchor or bolt and torque according to the manufacturer's instructions.

Piping, ductwork, and raceways may be connected.

END OF ATTACHMENT.

To additional structural steel shapes attached to the wall

Equipment attaches to the wall with additional structural steel shapes and bolts. Shapes may be welded. These steel shapes are attached to the building using concrete anchors, masonry anchors, or drywall anchors.

Figures 125 to 127 (pages 90-92) show how straps, angles and struts can be used for attachment to a wall. Angles and struts must accommodate wall construction attachment points and obstructions. Figure 159 (page 133) shows a strut attachment for equipment.

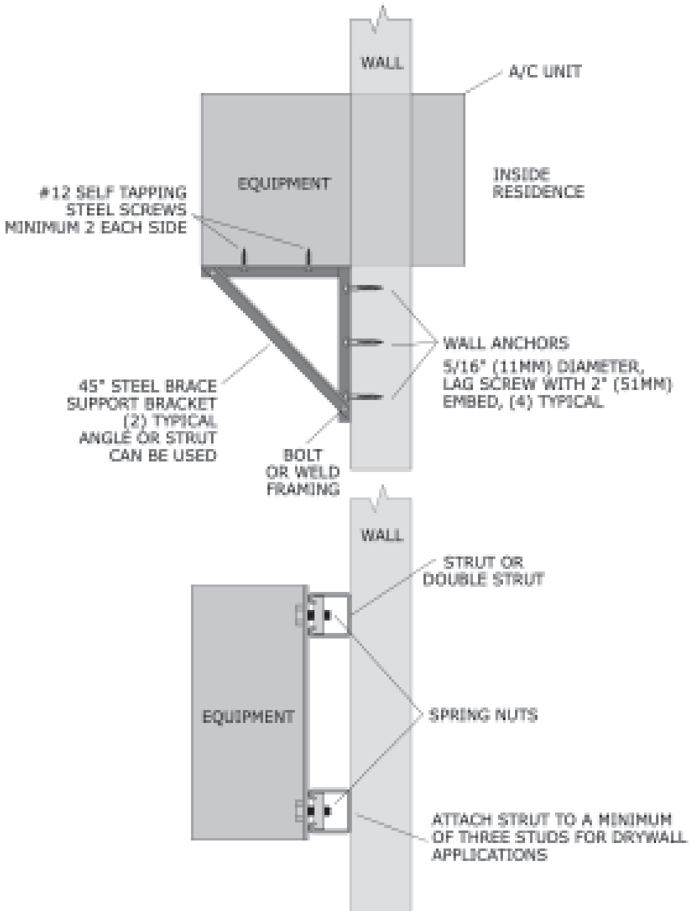


Figure 125: Angle or strut support.

A versatile attachment is an angle welded to a base plate, as shown in Figure 126 (below). This can be used for in-line piping specialties or for equipment. Two supports on each side of the equipment may be required. Rigid connection with rods and cables supported from the building structure above is optional.

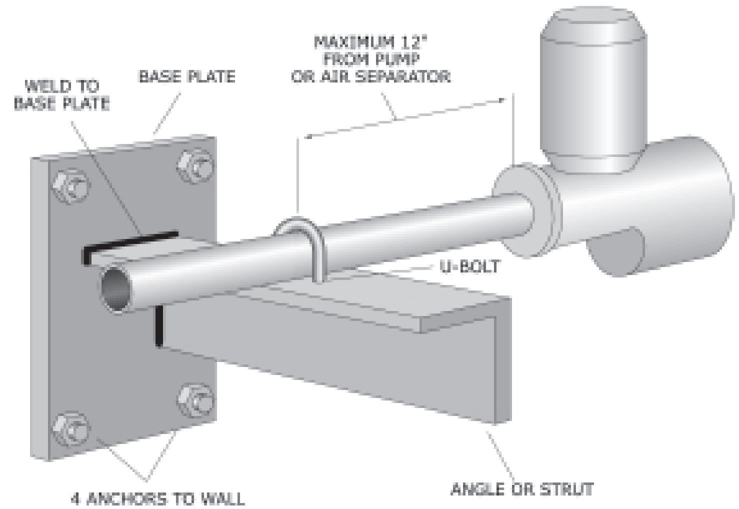


Figure 126: Angles welded to a base plate.

Water heaters or water tanks may be attached to the wall with a simple strap arrangement, as shown in Figure 127 (page 92).

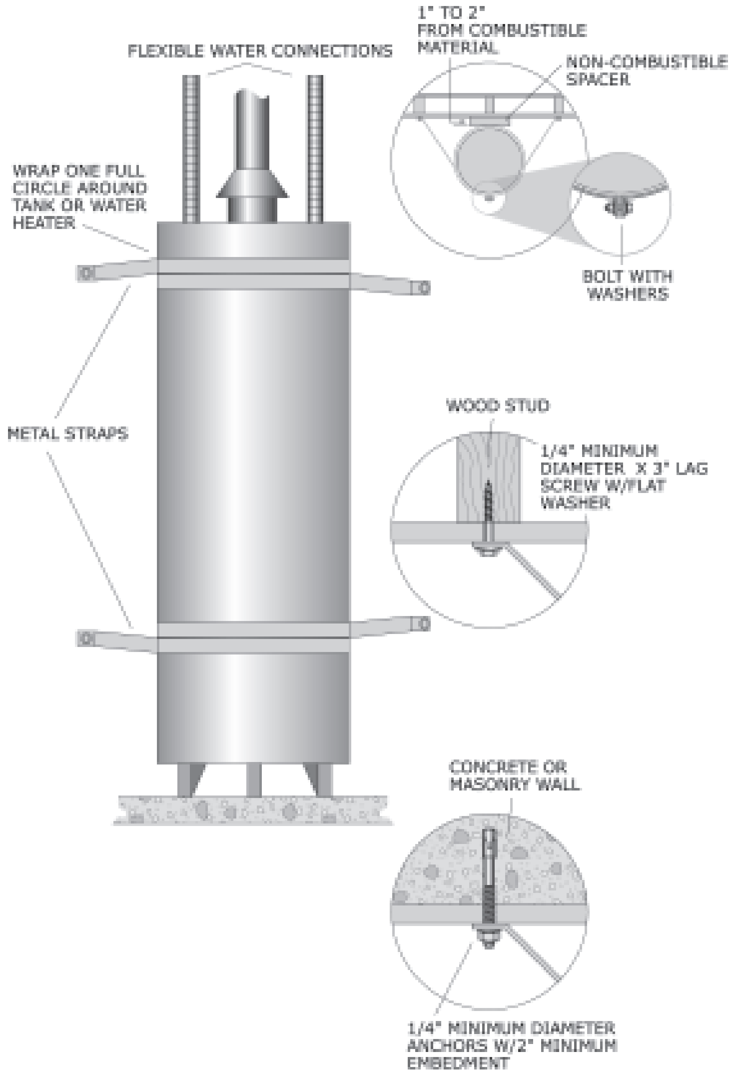


Figure 127: Water heater or water tank attachment.

Step 1: Determine the anchor locations

Find studs in drywall. Use measurements and construction drawings to lay out the bolt hole pattern and mark the anchor locations.

Attachment: Wall-mounted

Step 2: Install anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 96, or Masonry and Drywall Anchors, page 106).

Step 3: Move equipment into place and bolt to frame

You may drill additional holes into the equipment assembly or building steel beams as shown on construction drawings or the manufacturer's instructions.

New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 71 (page 35).

Piping, ductwork, and raceways may be connected.

END OF ATTACHMENT.

Vibration-isolated off the wall

Equipment attaches to the wall with additional structural steel shapes, threaded rods and vibration isolators. Shapes may be welded. These steel shapes are attached to the building using concrete anchors, masonry anchors, or drywall anchors.

Figure 128 (page 94) shows how rods, angles and struts can be used to isolate equipment attached to a wall. Angles and struts accommodate wall construction attachment points.

Vibration-isolated equipment prevents the transmission of noise and vibration into the building structure. See Figure 109 (page 71) for isolator detail.

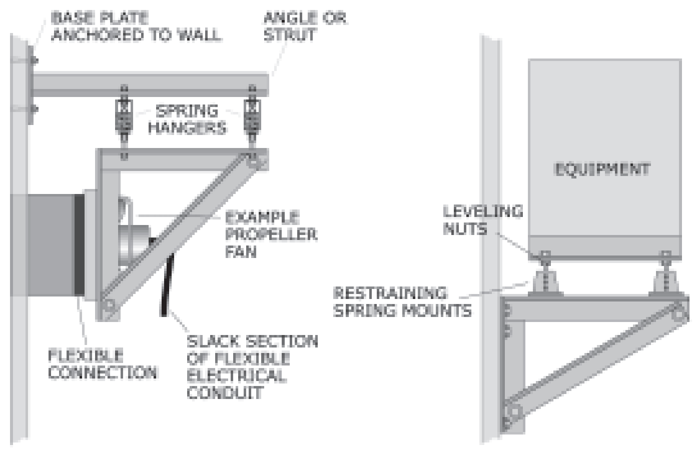


Figure 128: Wall-mounted, vibration-isolated equipment.

Step 1: Assemble wall frame with isolators

Accurately draw the bolt pattern on the wall using one of the following methods:

- Set the frame in place and mark the holes.
- Make a template.
- Use measurements and construction drawings to lay out the bolt hole pattern.

Step 2: Install anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 96, or Masonry and Drywall Anchors, page 106).

Step 3: Attach isolators, rod, and hang equipment

Attach the isolators to the framing. Attach the equipment to the isolators using threaded rod.

Piping, ductwork, and raceways may be connected.

END OF ATTACHMENT.

Directly to the wall—gas cylinders only

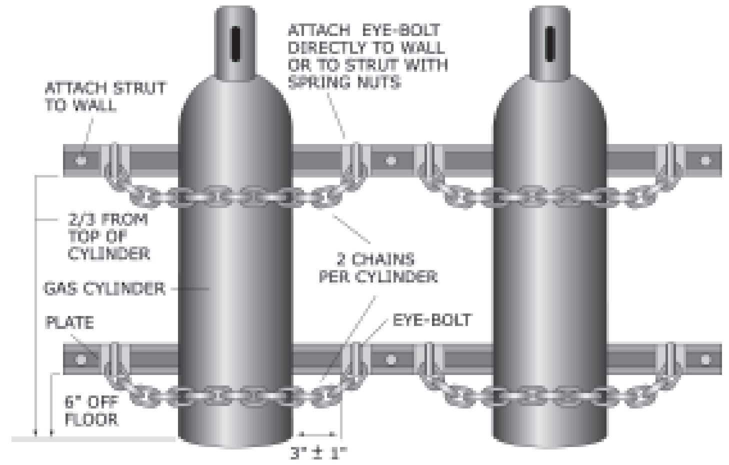


Figure 129: Gas cylinder supports.

Step 1: Assemble brackets

Accurately draw the bolt pattern on the wall using one of the following methods:

- Set the brackets in place and mark the holes.
- Use measurements and construction drawings to lay out the eye-bolt hole pattern.

Step 2: Anchor brackets or eye bolts to wall

If anchoring to concrete, install post-installed anchors (see Anchors, page 96, or Masonry and Drywall Anchors, page 106).

Step 3: Install chains to store gas cylinders in the upright position

Install two chains to restrain each cylinder. Install one chain across the cylinder near the top and one near the bottom.

Chains should fit snugly so there is little or no room for the cylinder to move.

END OF ATTACHMENT.

ANCHORS

General Anchors

IMPORTANT: Installation methods depend on the type of anchor and the particular application. Always follow the anchor manufacturer's installation instructions.

Figure 130: Types of anchors.

Step 1: Determine the type of anchor

Using Figure 130 (page 96), identify the anchor recommended for your application. Anchors 1-5 are post-installed anchors and instructions for installing them begin on this page. Anchors 6-10 are specialty anchors and instructions are shown on pages 103-120.

The various methods for installing anchors into concrete, brick, and concrete block anchors are shown below.

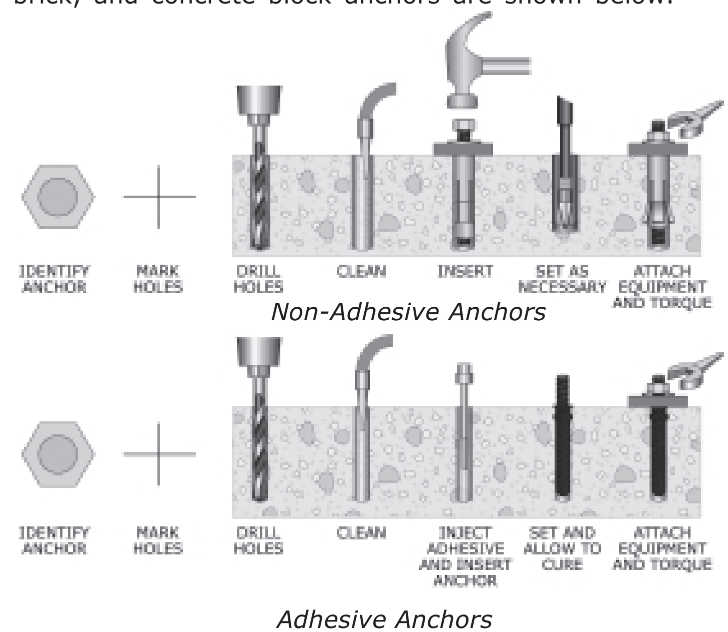


Figure 131: Summary of installation steps.

Contract documents may require special inspection to torque anchors or for proof load using hydraulic rams.

Step 2: Determine where to drill the hole

To determine anchor locations for the equipment you are installing, follow the instructions for the Attachment Type you are using (pages 32-95). Coordinate the equipment connections and hole locations with the location of any steel reinforcement or tendons.

Determine the depth and location of any steel reinforcement or tendons *before* drilling. This may require relocating equipment slightly to avoid the reinforcement.

FOR POST-TENSIONED BUILDINGS, LOCATE THE TENDONS BEFORE DRILLING. EXTREME DAMAGE MAY OCCUR IF A TENDON IS NICKED OR CUT.

When using electronic locating devices to find reinforcement and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precision of the test unit and record the results. For example: *agreed upon mark +/- ¼" location vertical, horizontal, and depth +/- ½".*

Coordinate the location of anchors with the edge of the concrete, construction joints, and other anchors.

Do not install the anchor too close to the edge of the concrete base. Typically the anchor's distance from the edge is 1½ times the embedment depth.

Do not install an anchor too close to another anchor. Typically the minimum spacing between anchors is two times the anchor's embedment depth.

Step 3: Drill the hole

Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.

Do not drill holes into concrete at an angle.

For wedge, undercut and sleeve anchors, drill the hole deeper than the required embedment depth.

The required hole depth may be different from the embedment depth. See Figure 132 (page 99).

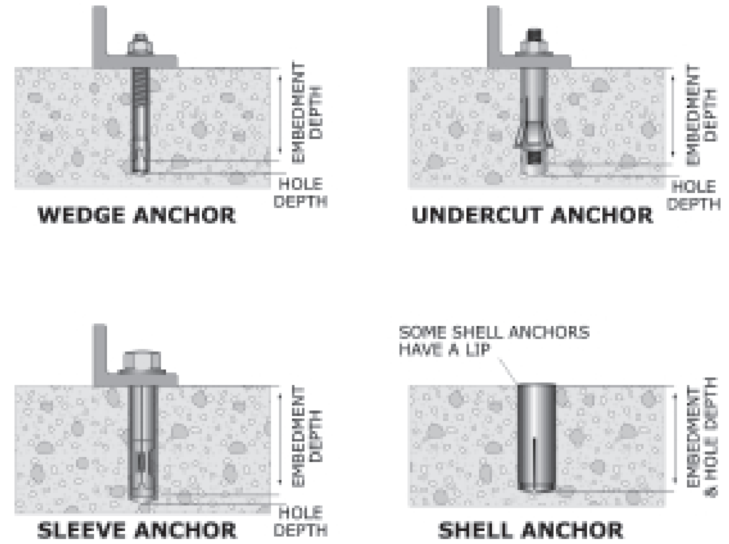


Figure 132: Embedment depth and hole depth of four anchor types.

The depth of the concrete base must be at least one inch greater than the hole you are drilling.

Some undercut anchors require an even deeper concrete base.

If you strike steel reinforcement when drilling, you must have the damage inspected. As directed, fill the hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see below).

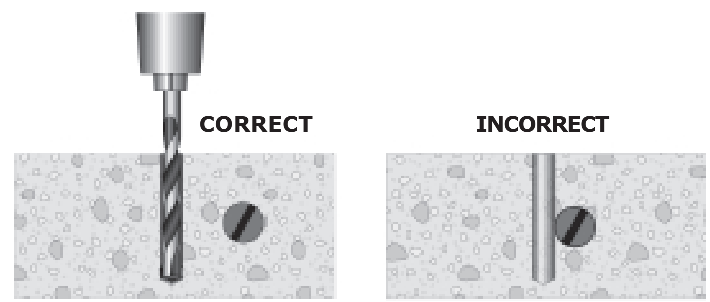


Figure 133: Drilling into concrete with rebar.

Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use water or a brush.

See the anchor manufacturer's instructions for cleaning the hole.

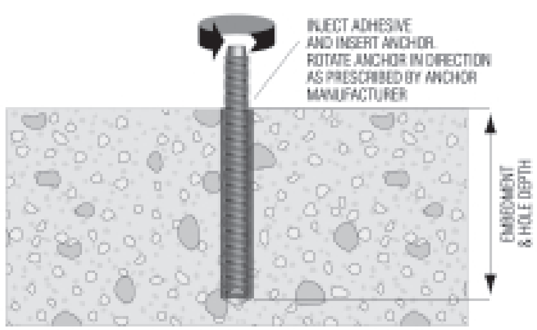
Cleaning is important: a "dirty" hole can significantly reduce an anchor's performance.

Step 5: Insert the anchor

If you are installing any anchor *other than* an adhesive anchor, drive the anchor into the hole with a hammer.

IMPORTANT: DO NOT DAMAGE THE THREADS DURING INSTALLATION. DO NOT FORCE THE ANCHOR. If you use a larger hammer than recommended by the manufacturer, you may damage the anchor.

If you are installing an adhesive anchor, insert the capsule or inject non-capsule adhesive into the hole. Slowly rotate the anchor into place as shown below.



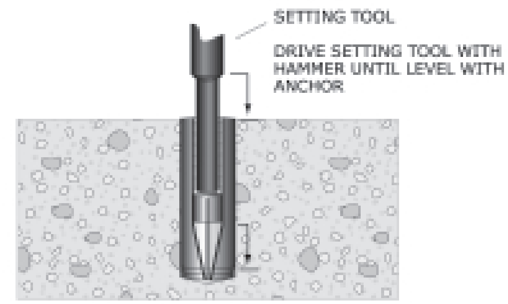
ADHESIVE ANCHOR

Figure 134: Adhesive anchor installation.

If you have installed a wedge or sleeve anchor, go to Step 7.

Step 6: Setting shell, adhesive and undercut anchors ONLY

Shell Anchor: Drive the prescribed setting tool into the anchor until the setting tool shoulder meets the edge of the anchor, as shown below.

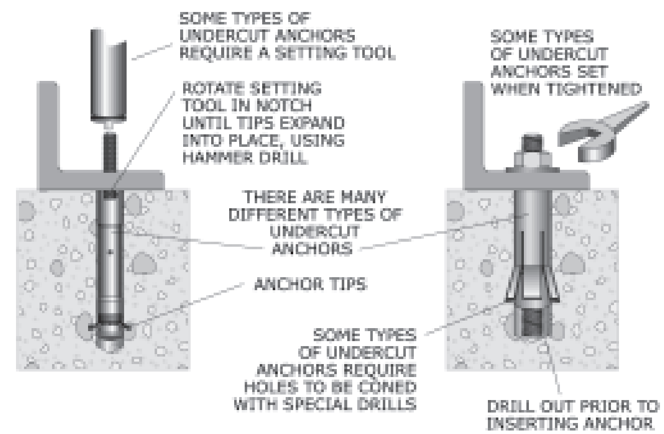


SHELL ANCHOR

Figure 135: Set shell anchors.

Adhesive Anchor: Allow enough time for the adhesive to fully cure. The curing process may take a long time. See the manufacturer's instructions.

Undercut Anchor: Use special tools provided by the anchor manufacturer to set the anchor, as shown below.



UNDERCUT ANCHORS

Figure 136: Set undercut anchors.

Step 7: Set the equipment and tighten the anchors

Set the equipment in place. Check for gaps. Gaps under the equipment must not be greater than 1/8" as shown below. If the gap is greater than 1/8", dry pack the gap with grout and repeat this step.

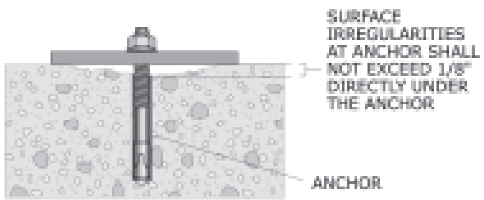


Figure 137: Acceptable gap for grouted plate.

Do not bolt equipment directly to concrete anchors where equipment sheet metal is less than 16 gauge if the anchor is larger than 3/8" in diameter.

For anchor bolts larger than 3/8", the equipment housing should be reinforced using a structural angle bracket as shown in Figure 138 (below).

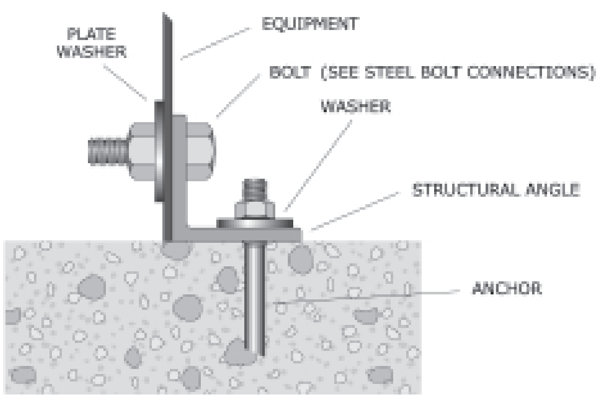


Figure 138: Installing a reinforcing angle bracket to equipment.

Tighten the anchor bolt to the correct torque setting in the manufacturer's instructions or construction drawings. Use a calibrated torque wrench.

Cast-in-place Anchors

Cast-in-place anchors are embedded in the concrete when the floors or walls are poured. Bolts are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the anchors can be determined from construction drawings.

Step 1: Move the equipment into place and attach the bolts

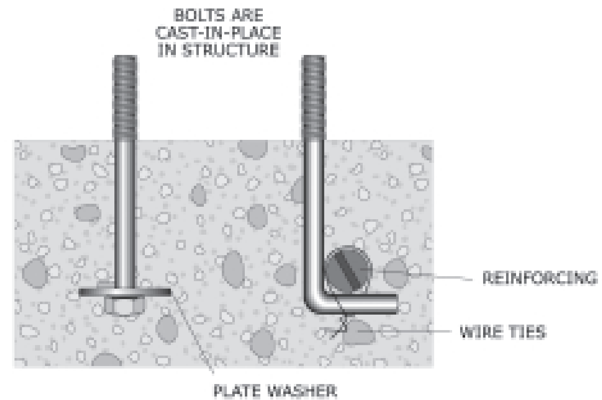


Figure 139: Bolting equipment to cast-in-place anchors.

Step 2: Place and secure equipment

Once the equipment is in place, apply washers and nuts and then tighten.

Tighten the anchor bolt to the correct torque setting in the manufacturer's instructions or on the construction drawings.

Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 115).

Lag Bolts

Lag bolts are used to attach equipment or steel shapes to wood structures. The size and location of the anchors can be determined from construction drawings (see Figure 140, below).

- The edge distance is 1½ times the bolt diameter.
- The spacing between bolts is 4 times the bolt diameter.
- The end distance is 7 times the bolt diameter.

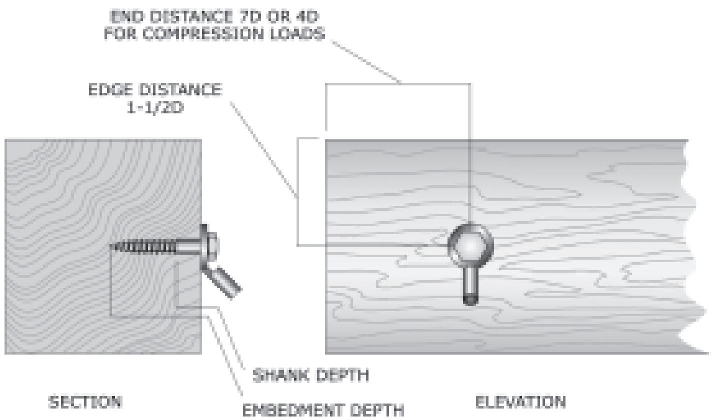


Figure 140: Spacing requirements for wood lag bolts.

Step 1: Mark the location of the lag bolts

Lead holes and clearance holes are not required for lag bolts that are 3/8" or smaller. If the lag bolt is smaller than 3/8", go to Step 4.

Step 2: Drill a clearance hole

Drill a hole with a drill bit the same size as the shank of the bolt. The depth of the hole is the same as the length of the unthreaded shank that will extend into the wood (see Figure 140, above).

Step 3: Drill a lead hole

Drill a hole with a drill bit that is 60% to 70% of the diameter of the shank of the bolt. The depth of the hole is the same as the embedment depth of the bolt (see Figure 140, page 104).

Step 4: Move the equipment or steel shape into place

Step 5: Drive the lag bolt in with a wrench

You may use soap or other lubricant on the lag bolt.

DO NOT USE A HAMMER TO DRIVE IN LAG BOLTS.

Step 6: Tighten the bolt

Hand-adjust the lag bolt where there is firm contact between the lag bolt and connected metal components. Tools may be used to bring the lag bolt and metal components into contact until the components are snug tight.

Masonry and Drywall Anchors

Step 1: Determine the type of anchor

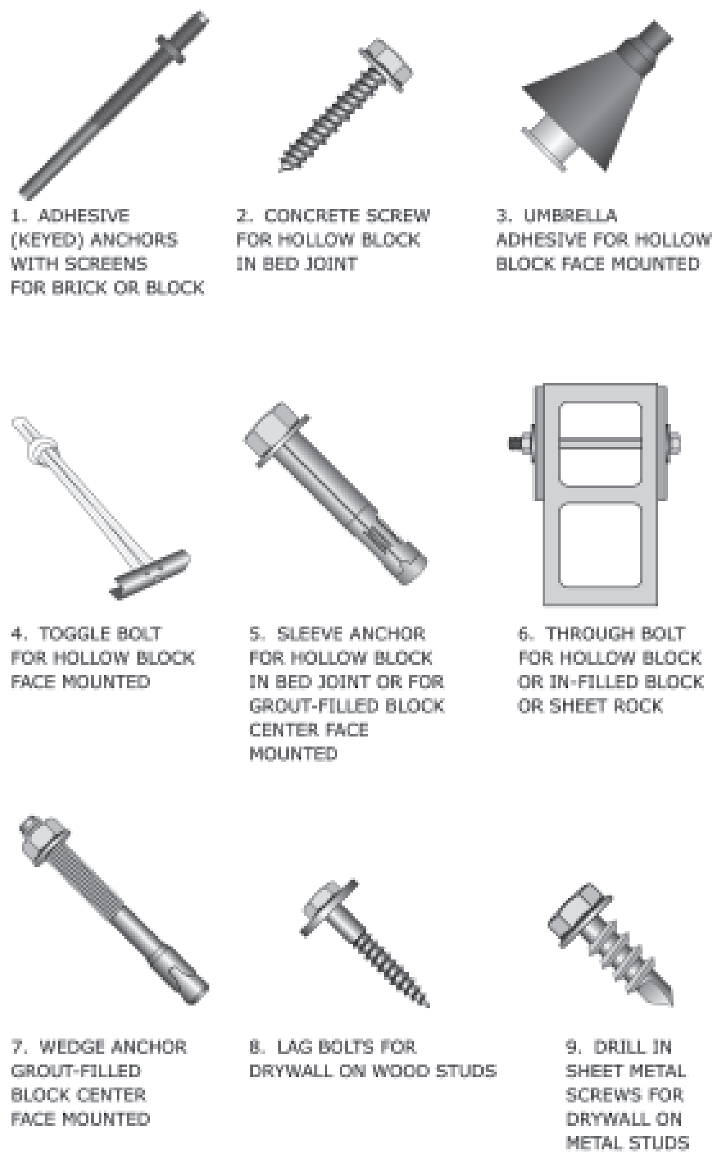


Figure 141: Types of masonry and drywall anchors.

Step 2: Determine where to drill the hole

Anchors shown in Figure 141 (page 106) must be installed in specific areas of hollow block and in-filled block. See Figure 142 (below) for approved anchor hole locations when using any of the concrete block anchors shown in Figure 141.

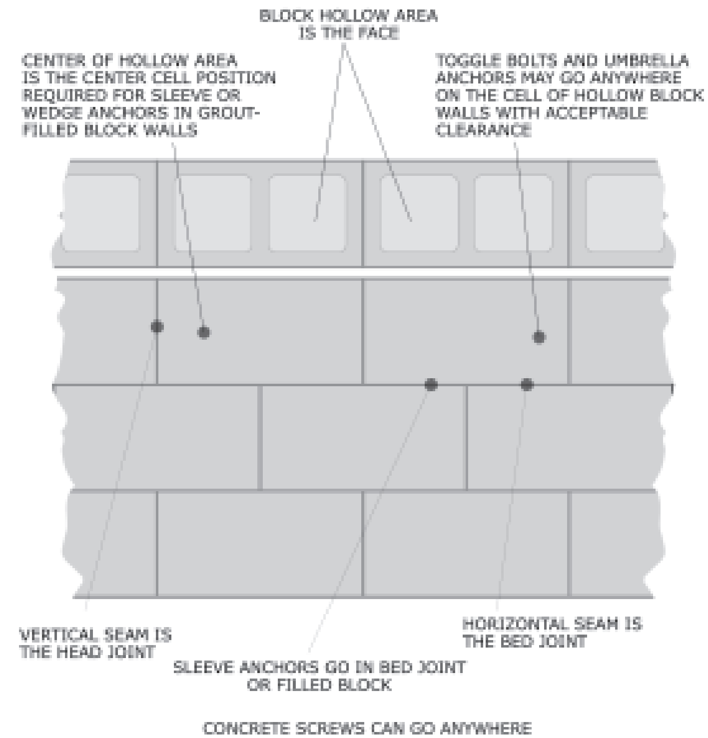


Figure 142: Block wall locations.

The location of the anchors should be coordinated with the block webs, or centered in the cell face, *and properly spaced from other anchors.*

DO NOT POSITION THE HOLES IN THE HEAD JOINT. Carefully note the location of anchors in the face location, centered face location, and bed joint as they apply to different anchors.

Find webs in block walls, reinforcement in grout-filled walls, or studs in drywall. Location of through-bolts: Avoid webs in concrete block and studs in drywall walls.

Location of lag bolts and sheet metal screws in drywall: Install in a wood or metal stud as appropriate.

Determine the depth and location of any steel reinforcement in grout-filled block walls or brick before drilling. This may require relocating equipment slightly to miss reinforcement.

When using electronic locating devices to find reinforcements and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precision of the test unit and record the results. For example: *agreed upon mark +/- ¼" location vertical, horizontal, and depth +/- ½".*

Step 3: Drill the hole

Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.

Use masonry drill bits for brick and block.

DO NOT CUT STEEL REINFORCEMENT WHEN DRILLING HOLES.

If you strike steel reinforcement when drilling, you must have the damage inspected. As directed, fill the hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see Figure 133, page 99).

Holes for concrete screws are smaller than screw size. See the manufacturer's instructions for specific requirements.

Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use water or a brush.

See the anchor manufacturer's instructions for cleaning the hole.

Cleaning is important: a "dirty" hole can significantly reduce an anchor's performance.

Step 5: Insert the anchor

The following anchors use different insertion methods.

- Adhesive screen anchor in a brick wall or hollow block wall (this page).
- Adhesive anchor in a hollow block wall (page 110).
- Concrete screw (page 111).
- Toggle bolt (page 111).
- Concrete anchor (sleeve anchor or wedge anchor) (page 112).
- Drywall anchor (lag bolts and sheet metal screws) (page 112).

Adhesive screen anchor in a brick wall or hollow block wall

See the anchor manufacturer's instructions before connecting the anchor to a brick or hollow block wall.

A screen insert is shown in Figure 143 (page 110). Insert the screen in the wall. Inject the adhesive. Slowly insert the anchor with a twisting motion.

Screens may be filled with adhesive before inserting the screen into the hole.

For details on installing adhesive anchors in a brick wall, see Figure 144 (page 110). Similar installation applies to hollow block walls. Adjust the anchor by hand while the adhesive sets.

DO NOT TOUCH THE ANCHOR WHILE THE ADHESIVE IS CURING.

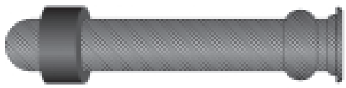


Figure 143: Brick/block wall insert.

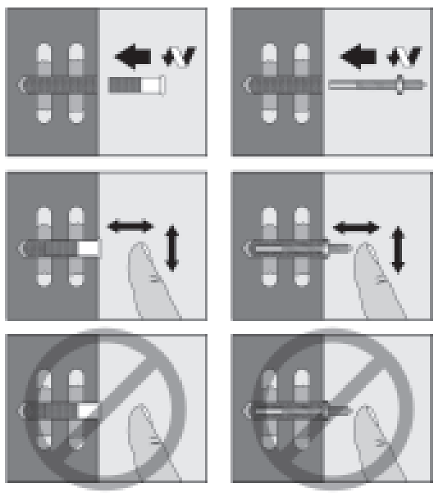


Figure 144: Brick wall adhesive anchor.

Adhesive anchor in a hollow block wall

See the anchor manufacturer's instructions before connecting the anchor to a hollow block wall.

Push an umbrella anchor into the hole until the umbrella unfolds in the block cavity. Inject adhesive into the umbrella. Slowly insert stud or fastener with a twisting motion.

DO NOT LEAK ADHESIVE ON THE THREADED PORTION OR CLEAN WITH SOLVENT. The threaded area must be free of debris to attach to a threaded rod or steel bolt.

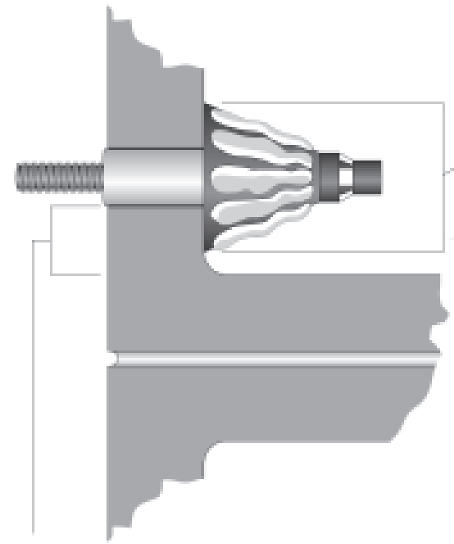


Figure 145: Umbrella anchor in a hollow block wall.

Concrete screw

Drill bits may be specifically sized for each manufacturer, and typically are smaller in diameter than the nominal or fractional diameter of a screw. Install a concrete screw with a rotary drill and bolt the head attachment.

Toggle bolt

Hold the toggle flat alongside the plastic straps and slide the channel through the hole. Slide the holding ring toward the wall until the channel is flush with the wall. Cut off the straps at the holding ring. Insert the bolt with a rotary drill over the bracket or equipment mounting.

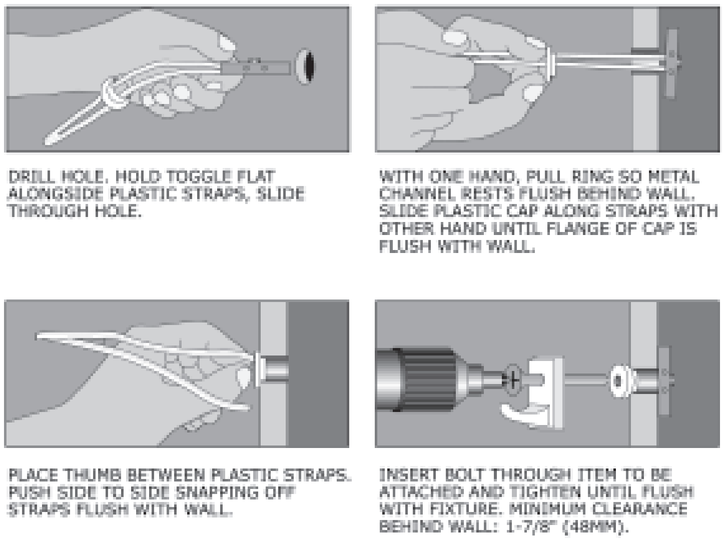


Figure 146: Toggle bolt installation.

DO NOT OVER-TIGHTEN.

Concrete anchor (sleeve anchor or wedge anchor)

Use a hammer to drive the anchor in the hole.

DO NOT FORCE THE ANCHOR. If you use a hammer larger than recommended, you may damage the anchor.

To determine the embedment depth of post-installed anchors, see Figure 132 (page 99).

Drywall anchor (lag bolts and sheet metal screws)

Use a rotary drill to insert the anchor.

DO NOT OVER-TIGHTEN.

Step 6: Set the anchor (adhesive only)

Allow enough time for the adhesive to harden and adhere to the concrete. *This may take several hours.*

Step 7: Set the equipment and tighten the anchors

Tighten the anchor bolt to the proper torque setting as shown in the anchor manufacturer's instructions or construction drawings.

In-filled block walls will have gaps in the grout fill or the grout will slightly crack, requiring anchors to be installed in the center of the cell.

If the grout cracks severely, or if you miss a grouted block, the anchor will not tighten and will pull out. If it pulls out, move the anchor to a new centered cell location.

Steel Bolt Connections

The three ways to attach bolted connections are:

- Connecting the base of the equipment to an angle bolted to a concrete floor (this page).
- Bolting two structural steel shapes together (page 116).
- Bolting a threaded rod to steel shapes or strut (page 116).

Connecting the base of the equipment to an angle bolted to a concrete floor

Step 1: Preparation

Determine the bolt size or sheet metal screw and material requirements from construction drawings or printed instructions supplied by the manufacturer.

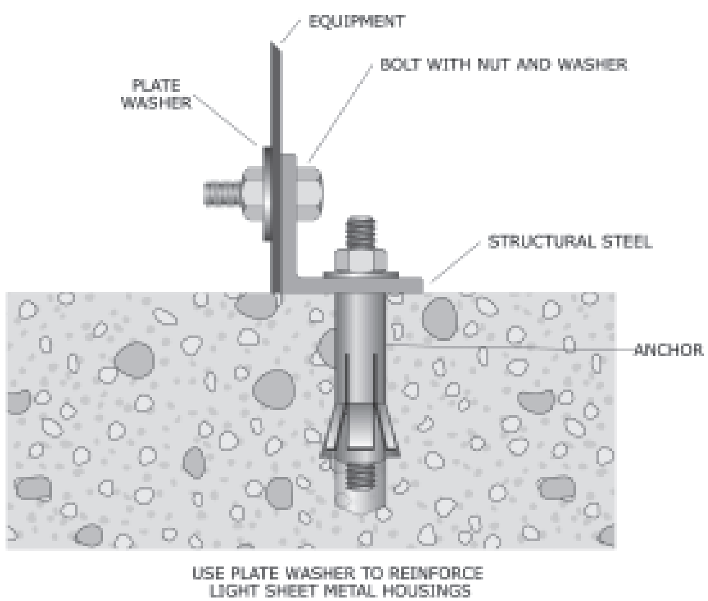


Figure 147: Bolting equipment to an angle.

Step 2: Locate holes

Use pre-drilled holes wherever possible. Holes may not have been pre-drilled at the attachment locations shown in the instructions. In these cases, carefully drill new holes in the correct locations.

Use caution when drilling into equipment. Internal components can be damaged. DO NOT DRILL OVERSIZED HOLES. See Figure 71 (page 35) for repair of oversized holes.

Step 3: Install bolts, washers, and nuts

Once the equipment is in place, apply washers and nuts and then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or the construction drawings.

For turn-of-nut tightening, hand-adjust the bolt snug tight where there is firm contact between the bolt and connected metal components. Tools may be used to bring the bolt and metal components into contact. Following contact, tighten the nut as shown below.

Length of Bolt	*Additional Tightening*
Up to and including 4 diameters	1/3 turn
Over 4 diameters and not more than 8 diameters	1/2 turn
Over 8 diameters and not more than 12 diameters	5/6 turn

Table 15: Hand-adjusted tightening.

Bolting two structural steel shapes together

Step 1: Preparation

Determine the bolt size and material requirements from construction drawings or the manufacturer's instructions.

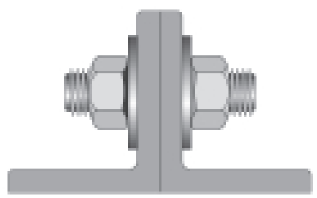


Figure 148: Bolting structural shapes.

Step 2: Locate holes

Carefully drill new holes in the structural steel shapes.

Step 3: Install bolts, washers, and nuts

Apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or the construction drawings. Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 115).

Bolting a threaded rod to steel shapes or strut

A threaded rod is used with suspended equipment. This section includes attachment to the equipment and attachment at the top (see Suspended Attachment, page 62).

Step 1: Preparation

Determine the threaded rod size from construction drawings or printed instructions supplied by the manufacturer.

The three different ways to attach the threaded rod are shown in Figure 149 (below).

Step 2: Attach the top connection of the threaded rod

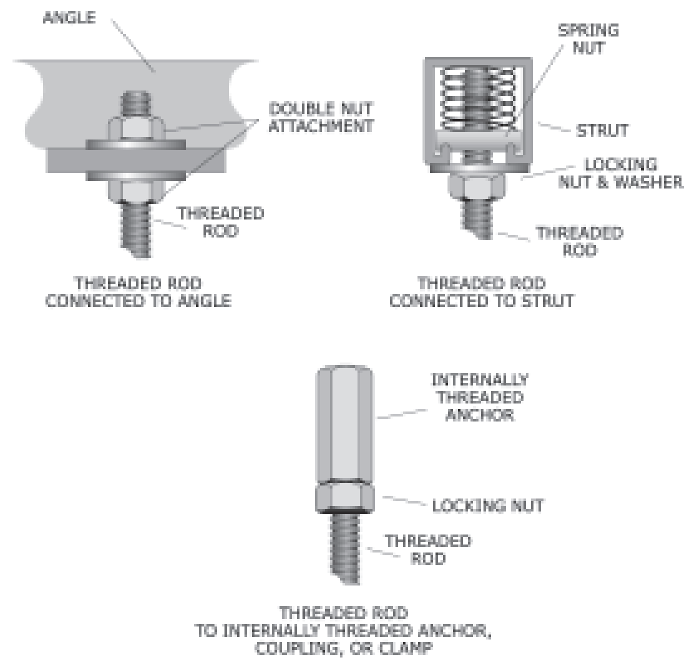


Figure 149: Attaching the top of threaded rod.

Apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or the construction drawings. Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 115).

Step 3: Attach threaded rods to equipment brackets

Equipment without attachment brackets requires additional steel shapes for connections to the building structure and/or roof.

Once the equipment is in place, apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or the construction drawings. Use a calibrated torque wrench or turn-of-nut method (see Table 15, page 115).

Welding

Before welding, refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Attaching equipment to embedded plates: Plates are embedded in the concrete during the floor or wall pour. Plates are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the plate can be determined from construction drawings. See Figure 150 (below) for weld locations.

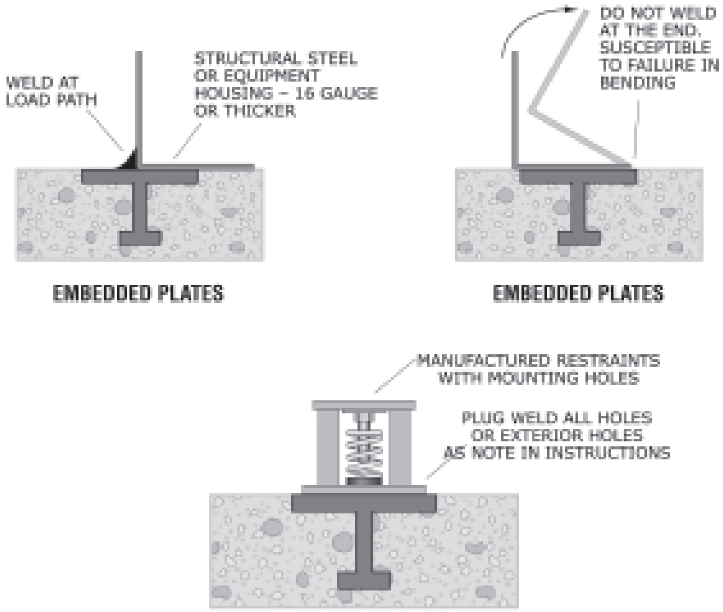


Figure 150: Welding to embedded plates.

Attaching structural shapes and plates: Shapes and plates are welded to provide equipment attachment. All weld base material must be thick enough for the weld size specified.

Step 1: Determine the weld material, shape, and dimensions for each piece

Step 2: Fit the material to ensure proper weld joint preparation

Step 3: Clean the surfaces

Surfaces must be dry and free of galvanized coating, hot-dipped or rust inhibitor, paint, scale, rust, oil, grease, water, and other foreign material for a minimum of one inch from the estimated toe of the weld.

Step 4: Weld the materials

The weld must be as prescribed in the welding procedure specifications (WPS).

WPS for shop and field pre-qualified weld joints and weld joints qualified by test must be prepared for review and approval before fabrication. All welding procedure items such as base metals, welding processes, filler metals and joint details that meet the requirements of AWS D1.1 Section 5.1 will be considered prequalified. Any change or substitution beyond the range or tolerance or requirements for pre-qualification will be qualified by test pre-AWS D1.1 Section 5 part B.

DO NOT WELD OVER PAINT. You may paint after welding has cooled to room temperature.

Step 5: Inspect the weld

Make sure the surface is free of slag, dirt, grease, oil, scale, or other contaminants.

Welds cannot have cracks. Adjacent layers of weld metal and base metal must be thoroughly fused together.

All craters must be filled to the full cross-section except outside the effective weld length.

Underrun must not exceed 1/16”. Undercut must not exceed 1/16” for any 2” per 12” weld or 1/32” for the entire weld.

Surfaces must be free of coarse ripples, grooves, abrupt ridges, and valleys. The faces of fillet welds must be flat or slightly convex.

Anchor Sizes for Equipment Weighing Less than 400 Pounds

Rigid floor-mounted equipment

Bolt equipment to a concrete floor or weld to a steel beam according to Table 16 (below). Install one anchor at each corner. Torque anchors according to the manufacturer’s instructions.

Anchor	*Embedment (in.)*	*Minimum Edge Distance (in.)*
1/4" wedge	2"	3" to edge of concrete
3/8" sleeve	1-1/4"	2" to edge of concrete
1/8" weld	1" long at each corner	N/A

Table 16: Rigid floor-mounted anchor sizes.

These anchor/weld selections apply to equipment in which the height of the center of gravity (center of equipment mass) is less than twice the base length AND twice the base width.

Roof-mounted equipment

Anchor equipment to concrete deck, a wood beam, or directly to a steel structural shape according to Table 17 (page 122). Install one anchor at each corner. Torque anchors according to the manufacturer’s instructions.

Anchor	Embedment (in.)	Minimum Edge Distance (in.)
1/4" wedge	2"	3"
3/8" sleeve	1-1/4"	2"
3/8" lag bolt to a 2x4 wood beam (min.)	1-1/2"	5/8" to edge of wood and 3" from end
1/4" steel bolt	N/A	1/2"
1/8" weld	2" long at each corner	N/A

Table 17: Roof-mounted anchor sizes for rigid connections.

These anchor/weld selections apply to equipment in which the height of the center of gravity (center of equipment mass) is less than twice the base length AND twice the base width.

Suspended equipment

Rigidly attach equipment to building structure above with angles or rods and cables according to Table 18 (below and next page). Torque anchors according to the manufacturer's instructions.

Vertical threaded rod	Quantity	Anchors per Rod
1/2" rod with rod stiffener	One on each corner	1

Table 18: Suspended equipment anchor sizes for rigid connections (table continued on next page).

Rod anchor	Embedment (in.)	Minimum Edge Distance
1/2" wedge	2-1/4"	3-1/2"
1/2" sleeve	2-1/4"	3-1/2"
3/8" lag bolt to a 2x4 wood beam (min.)	2"	5/8" to edge of wood and 3" from end
1/2" steel bolt	N/A	1"

Cable	Quantity	Anchors per cable
1/8" pre-stretched aircraft cable	4 at 45 degrees from each corner	1

Cable anchor	Embedment (in.)	Minimum Edge Distance (in.)
1/2" wedge	2-1/4"	3-1/2"
1/2" sleeve	2-1/4"	3-1/2"
3/8" lag bolt to a 2x4 wood beam (min.)	2"	5/8" to edge of wood and 3" from end
1/2" steel bolt	N/A	1"

Table 18 (continued): Suspended equipment anchor sizes for rigid connections.

SPECIAL CASES

Cables

The three ways to assemble a cable connection are by using:

- Bolts with center holes (page 125).
- Ferrule clamps (page 126).
- Wire rope grips (page 128).

Other end fittings may be acceptable.

Cables should be installed at a 45-degree slope. Where interferences are present, the slope may be a minimum of 30 degrees or a maximum of 60 degrees.

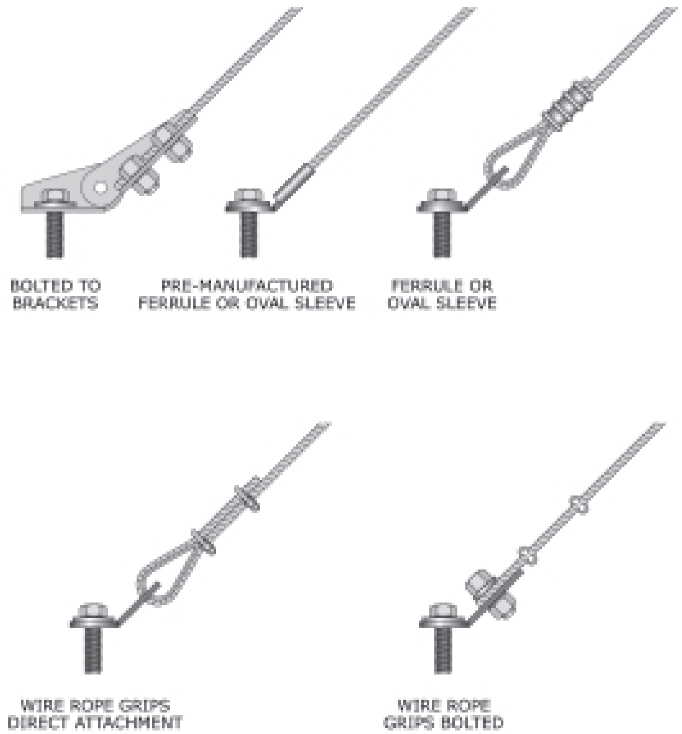


Figure 151: Cable attachments.

Bolts with center holes

The manufacturer provides this type of cable assembly, along with the cables, mounting bolts with holes, and brackets that attach directly to the building structure or equipment frame. Assemble the cable as shown below.

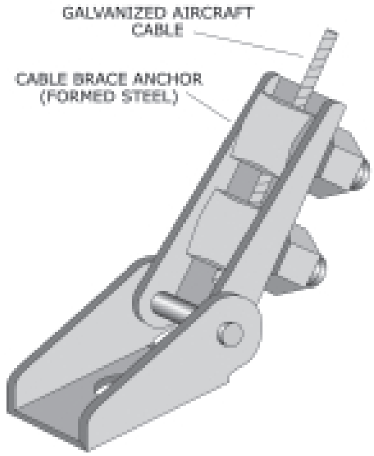


Figure 152: Cable attached with bolts to a bracket.

Step 1: Drill anchor holes in the building structure as required

Step 2: Attach brackets to both the building and the equipment frame

Step 3: Cut the cable to desired length and slide it through the holes in the bolts

Step 4: Tighten the cable

For rigid connections, pull the cable hand tight. Pull the cable hand-tight and let out 1/8" for vibration-isolated components. Avoid using too much tension or too much slack.

Step 5: Torque bolts

Refer to the manufacturer's instructions.

Ferrule clamps

Ferrule clamps may be connected to various types of attachments. Figure 153 (below) and Figure 154 (page 127) show attachments and identify the parts ferrules or sleeve and thimbles used in the assembly.

Ferrules must be made of steel, zinc-plated copper, or steel alloys (including stainless steel). Do not use aluminum ferrules.

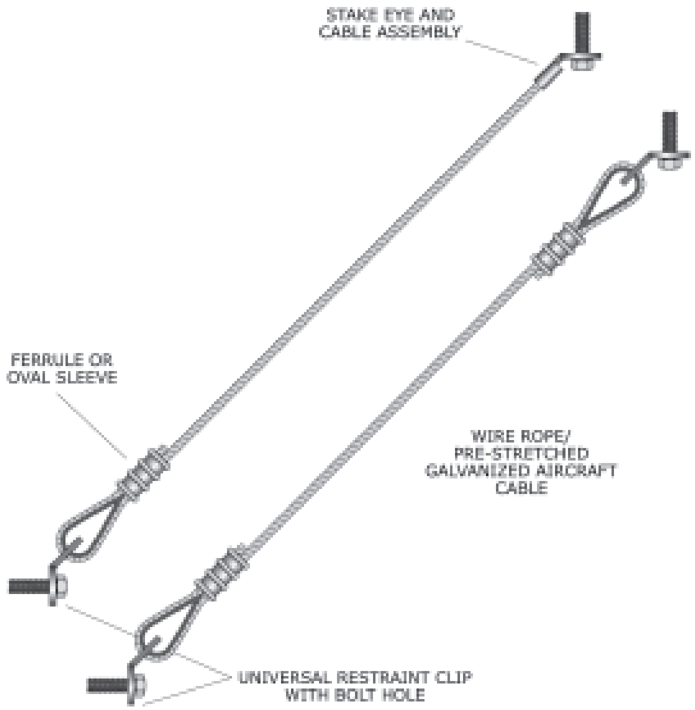


Figure 153: Ferrule assemblies.

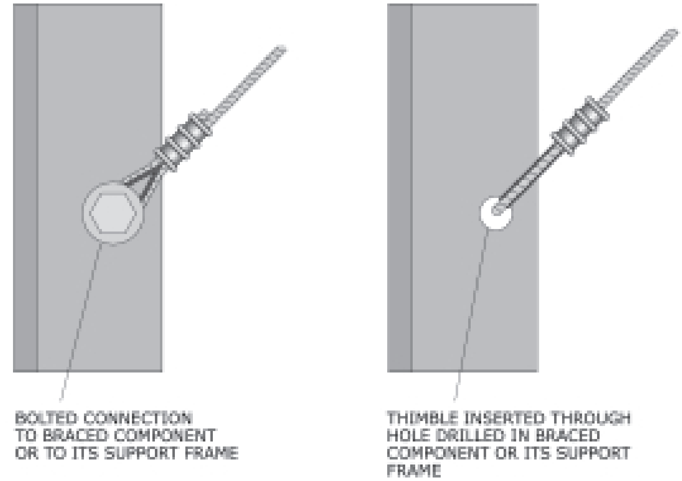


Figure 154: Ferrule attachments.

Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes

Install brackets with mounting holes to the structure. Attach cables to the top of cord angles. See Suspended Attachment (page 62).

Step 2: Cut the cable to the desired length and slide the oval ferrule (sleeve) onto the cable

Step 3: Wrap the cable around the thimble and pass it through the mounting bolt or holes and back through the ferrule

Step 4: Tighten the cable

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

Step 5: Crimp the ferrule or oval sleeve two or three times as specified in the cable or ferrule manufacturer's instructions

Use crimp tools and gauges specified by the manufacturer. Crimp and verify the depth of the crimp using a gauge.

Wire rope grips

Installing cables attached with wire rope grips is similar to attaching ferrule clamps, as shown below.

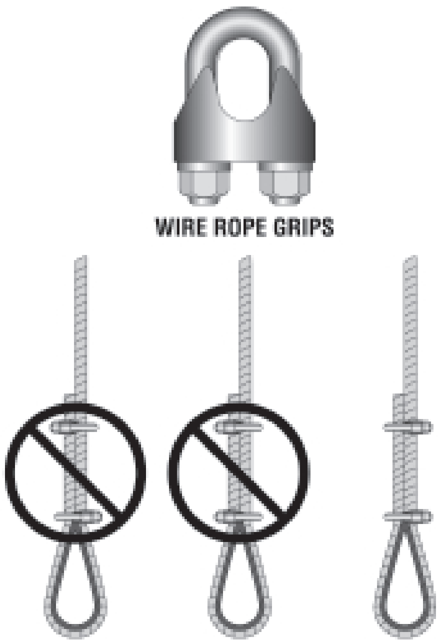


Figure 155: Wire rope grip assemblies.

Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes

Step 2: Cut cable to the desired length and slide three wire rope grips and thimbles onto the cable

Step 3: Pass the cable through the mounting bolt or holes provided and then back through each of the wire rope grips

Use thimbles for all cable installations with wire rope grips.

Step 4: Tighten the cable

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

Step 5: Torque all bolts evenly

Use the turn-of-nut tightening method described in Steel Bolt Connections (page 114).

DO NOT OVER-TIGHTEN.

Control Panels

Control panels may be built into units, mounted in a separate electrical panel attached to equipment assemblies, or mounted as a separate electrical panel attached to the building structure.

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and the manufacturer's instructions.

If an electrical panel is mounted separately from the unit and the unit is vibration-isolated, use flexible electrical connections to allow for differential movement.

Step 1: Select control panel support configuration

If the control panel is:

- Built into the equipment, no other action is needed.
- An electrical panel attached to the assembly, check that the attachment is rigid and tight. No other action is needed.
- A remote panel attached directly to the building structure or attached using support angles or strut, continue with the following instructions.

The four ways of supporting control panels are by attaching them to:

- Walls with wall anchors as shown in Figure 159 (page 133).
- Vertical angles or strut extending down to the floor with angles slanted back to the floor as shown in Figure 156 (page 131). This is the typical method. Details are shown in Figure 158 (page 132).
- A double-strut support spanning the floor and ceiling as shown on the right in Figure 157 (page 131). Struts are attached to the building structure with small angle clips.
- An aluminum plate extending from the floor to the ceiling. The aluminum plate is attached to the floor and ceiling with angles, as shown on the left in Figure 157 (page 131).

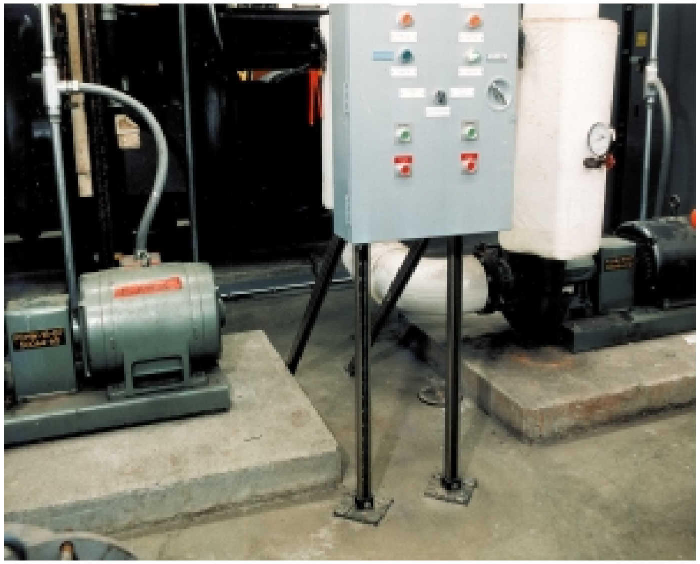


Figure 156: Typical control panel support using angles. Additional angle supports may be required (see below).

Figure 157: Two different ways to support control panels: using a metal plate attached to floor and ceiling with steel angles (left); using struts extending to floor and ceiling (right).

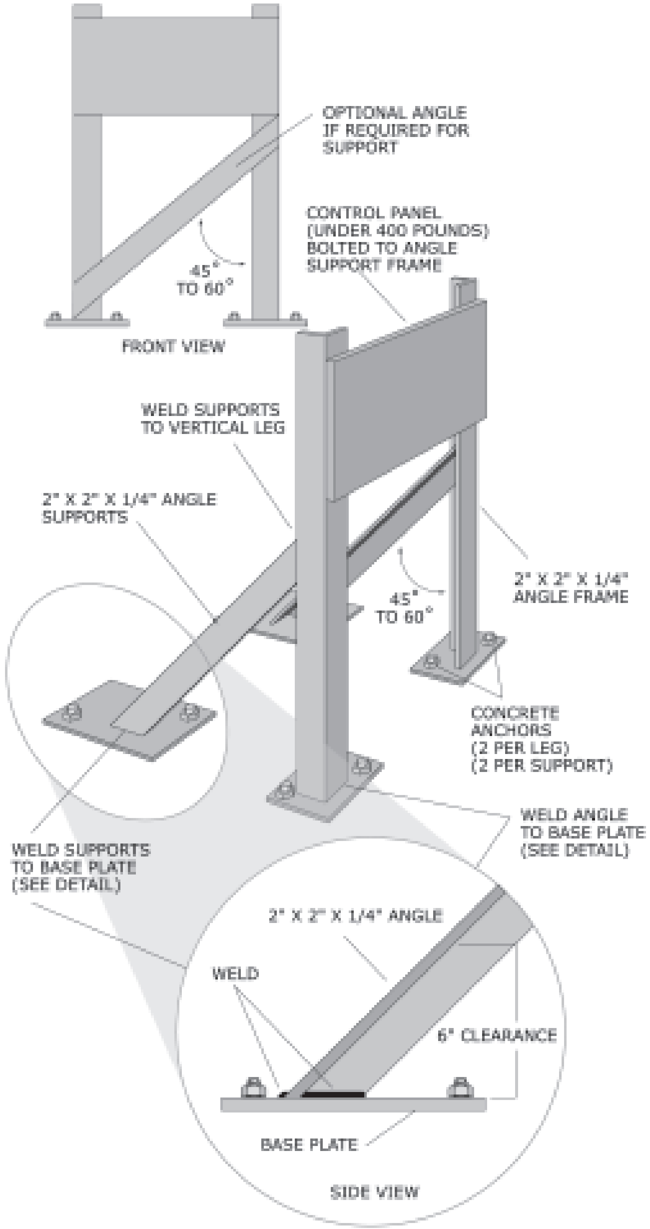


Figure 158: Angle assembly support from floor.

Special Cases: Control Panels

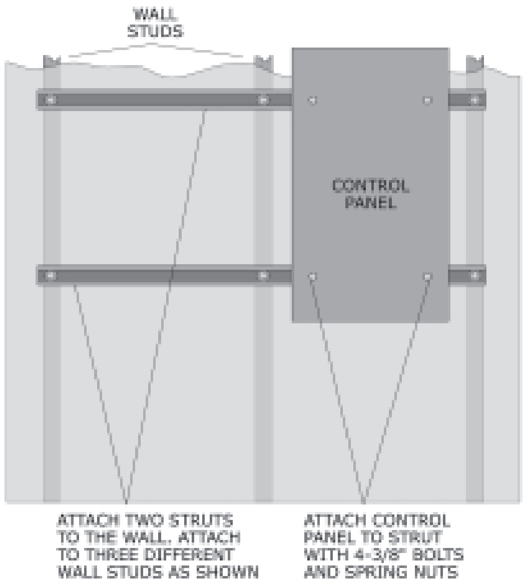


Figure 159: Direct attachment of a strut assembly support to wall.

Step 2: Assemble the mounting frame

Use bolts or weld the support framing together as shown in Figures 156 to 159 (pages 131-133). See Steel Bolt and Sheet Metal Screw Connections (page 114), or Welding (page 119) for more information.

Step 3: Attach the mounting frame to floor or wall with anchors

Locate and mark hole locations in the building structure. Install the anchors. See Anchors (page 96) for more information.

Attach the mounting frame to the building structure.

- To attach strut angles for strut floor-mounted supports, see Figure 157 (page 131).
- To attach bases for angle floor-mounted supports, see Figure 158 (page 132).
- To attach strut to wall studs, see Figure 159 (above).

Step 4: Attach control panel to frame with a minimum of 4 steel bolts

See Steel Bolt Connections (page 114).

Housekeeping Pads

Be sure to refer to contract drawings, specifications and the manufacturer's instructions.

The construction of housekeeping pads is shown below.

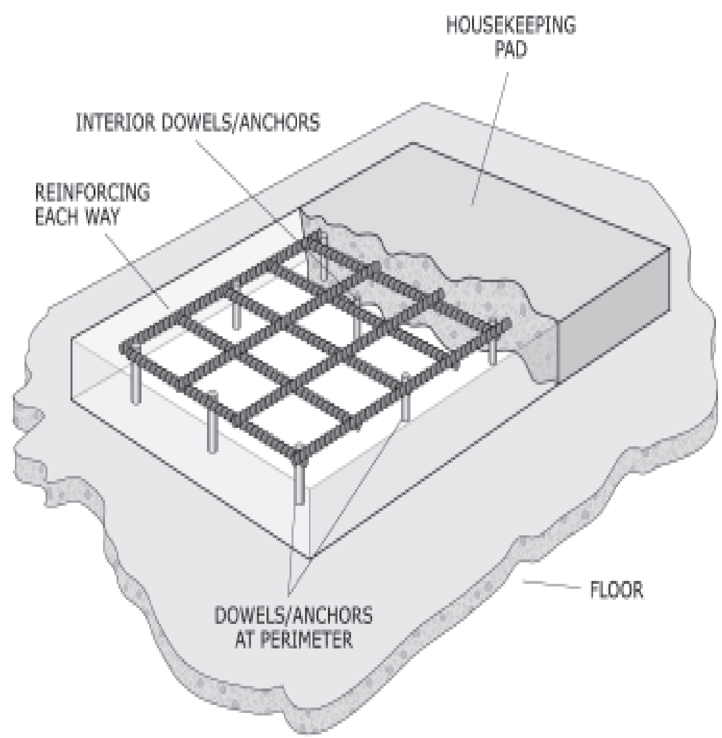


Figure 160: Housekeeping pad.

The housekeeping pad must be a minimum of one inch thicker than the anchor hole depth, or as required for the concrete anchors shown in Figure 161 (page 136).

Housekeeping pads must be designed for the equipment weight and seismic load.

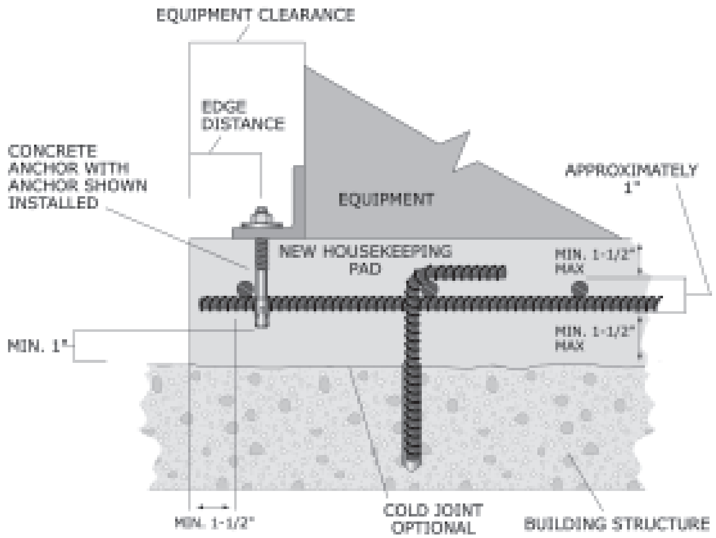


Figure 161: Housekeeping pad in section view.

If edge distance is not met, get an evaluation.

Dimensions for the pad footprint must be large enough for the equipment, attachment steel (as required), and the edge distance of concrete anchors (see Anchors, page 96), as shown in Figure 162 (below).

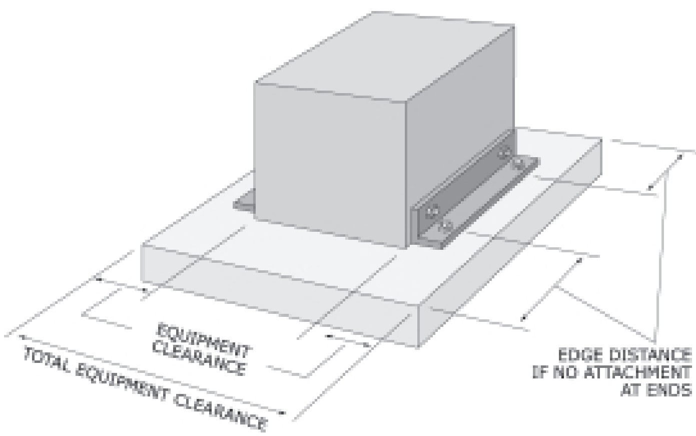


Figure 162: Housekeeping pad dimensions.

Step 1: Install dowels into the floor

Attachment details for dowels are shown in Figure 163 (below).

- Use measurements and shop drawings to lay out the size of the dowels and the dowel pattern.
- Coordinate the location of embedded “Z” bar shown in Figure 163 with the concrete subcontractor.

Obtain the size of doweling and reinforcement from contract drawings, specifications, or the manufacturer’s printed instructions. Exterior dowels must be ½” to 1” in diameter. Interior dowels must be ½” to ¾” in diameter.

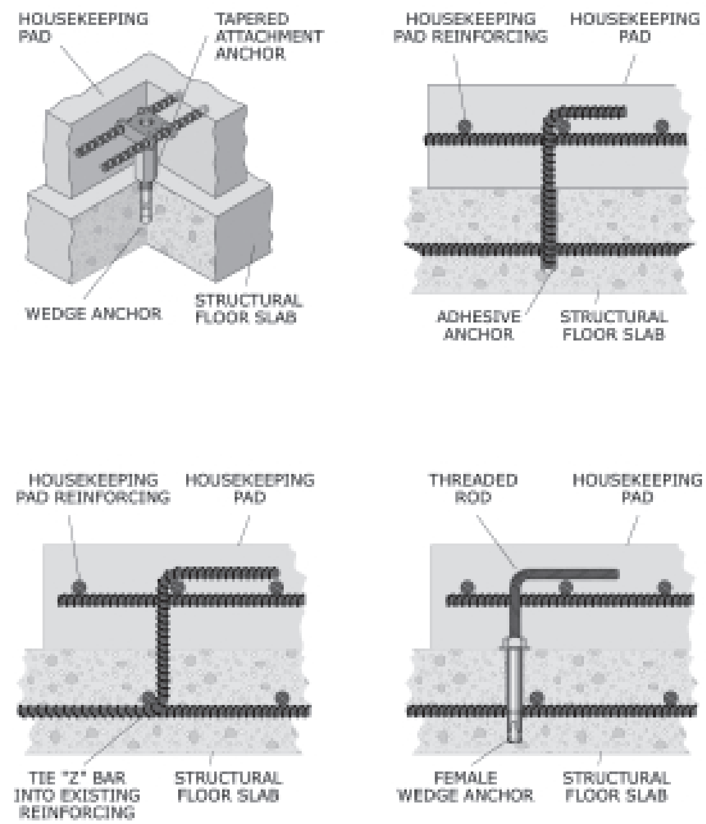


Figure 163: Doweling to the building floor.

Step 2: Assemble reinforcement

Assemble the reinforcement as shown in Figure 160 (page 135). Connect the dowels using wire.

Step 3: Pour concrete and allow to cure

Step 4: Drill holes and attach the equipment to concrete after the concrete has cured

Residential Equipment

Mechanical equipment in residential applications should be rigidly attached to the building structure or concrete pad. The types of equipment used for residential HVAC include:

- Water heater
- Furnace
- Condensing unit with an indoor A-coil attached to a furnace
- Through-the-wall air conditioner.

Water Heater

A water heater may be bolted to the residential structure with straps (see Figure 127, page 92). For gas water heaters below 100,000 BTUH, use flexible pipe to attach the water heater to the gas piping.

Furnace

A furnace may be bolted to the residential structure with straps and/or restrained at the bottom with bumpers. Straps may be attached to the residential structure in a manner similar to that of water heaters.

To use bumpers, see Figure 77 (page 41). To use straps, see Figure 127 (page 92). Bumpers may be constructed using wood studs for furnaces inside a raised closet.

For gas furnaces below 100,000 BTUH, use flexible pipe to attach the furnace to the gas piping.

Condensing unit

A condensing unit may be bolted to a concrete pad outside and next to the residential structure or mounted on the roof of the structure.

- For a condensing unit mounted on the roof, use a sheet metal curb with a wood nailer to attach the unit on the roof. See Figure 87 (page 52) for instructions on installing the curb. The curb must be firmly attached to the roof structure with lag bolts. Attach the condensing unit to the curb with lag bolts.

- For a condensing unit bolted to a concrete pad outside, attach the equipment using angles. See Figure 72 (page 37), Figure 73 (page 38), or Figure 76 (page 39).

A-coil

An A-coil may be attached on top of a furnace with sheet metal screws.

Through-the-wall air conditioner

An air conditioner should be attached to the residential structure. Some air conditioners have brackets used to directly attach the unit to the structure using lag bolts. A bracket support may be provided as shown in Figure 125 (page 90).

ANCHOR SELECTION GUIDE

Powder-Actuated	
Description	Warning
Threaded Studs Used in cases where the fastened equipment is to be removed later, or where shimming is required. Threaded studs for concrete have a 0.140" to 0.180″ shank diameter, with typical penetration of 3/4" (minimum) to 1-1/2" into concrete. Threaded studs for steel plate applications have a 0.140" to 0.180″ shank diameter when the steel plate thickness is 3/16" or greater. **Drive Pins** Used to directly fasten equipment for permanent installation. Drive pins used for concrete have a 0.140" to 0.180″ shank diameter, with typical penetration of 3/4" minimum to 1-1/2" into concrete. Drive pins for Steel plate applications have a 0.140" to 0.180″ shank diameter when the steel plate thickness is 3/16" or greater.	**Safety is the primary concern when using powder-actuated tools (PAT). PAT tools pose the greatest risk to the operator and others in the area of use. Observe the following safety precautions:** Typically not used for equipment weighing more than 40 pounds. Never allow a tool to be used until the operator is properly trained for the specific tool and application. Never use a tool unless all safety features are functioning properly. Always have the operator and others around wear the proper safety devices. Never use more powerful loads than required for the particular application. Always be aware of the potential of the fastener passing through the substrate or being deflected from its intended target. Make sure that all areas are clear behind and around the target area. Have an action plan in place to properly handle and dispose of misfired loads. Always make sure the tools are low velocity and not standard velocity. (Standard velocity tools are not typically allowed on most jobsites because of the danger.)

Adhesive	
Description	**Warning**
Capsule Spin-In Adhesive mixes in hole when anchor is drilled by a rotary hammer drill only. Various strengths and types of rods or fasteners can be used. Multiple types of coatings on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.	Do not over-spin during installation. The rod must have a roof cut end with a single or double 45-degree angle/bevel for mixing. The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong odors during the curing process.
Capsule Hammer-in Adhesive mixes in hole when a rod is driven by a hammer. Various strengths and types of rods or fasteners can be used. Multiple types of coatings on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.	The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong odors during the curing process.

Adhesive (cont.)	
Description	**Warning**
Epoxy Used by mixing two or more components with a mixing nozzle at the point of application. Can be used with multiple forms of fasteners or as an adhesive. Many brands can be used in wet, damp, or dry conditions. Many formulas are allowed for use for USDA food processing areas. Some may be able to be used overhead. Permitted many times in freeze-thaw and severe weather conditions. Allows minimal edge distance and anchor spacing. Typical shelf life greater than that of other adhesives used for anchoring. Not as susceptible to damage from high storage temperatures.	Typically requires long curing times compared to that of other adhesives. Can be virtually odor free or can emit a strong odor, depending on the formula. Can be difficult to apply if the epoxy is thick. Generally not suggested for use at temperatures below 32 degrees F. Most epoxies require holes to be cleaned to obtain maximum values.
Acrylic Adhesive Dispenses and cures quickly. Some adhesives can be used overhead. Some adhesives can be installed in damp or water-filled holes. Typically can be used with many fastening devices such as threaded rod, dowels, and anchors.	Many types of acrylics produce a strong odor during the curing process. Others have a minimal odor.
Adhesive Undercut Anchors Used in heavy-duty applications where substrate is of poor quality.	Generally purchased from the manufacturer as a complete anchoring system. Any substitution of materials must be authorized before installation.

Externally Threaded	
Description	Warning
Heavy Duty Undercut Used in heavy-duty applications. Typically two types: self-undercutting and adhesive. Self-undercutting types use a special undercutting drill bit are similar to heavy-duty sleeve anchors except they fill a cavity greater than the initial hole diameter.	May require special tools and specific drill bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.
Wedge Anchor The most common concrete anchor for heavy- to light-duty applications. Many configurations are available for most applications. Made from a variety of materials.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.
Heavy Duty Sleeve Anchor Expansion anchor for heavy-duty requirements.	A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If re-assembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or br detached from the expansion cone, requiring anchor replacement. These conditions are not visible.

Externally Threaded (cont.)	
Description	Warning
Center Pin Anchor Medium-duty expansion anchor. The anchor is correctly installed when the pin is completely inserted. Installation procedures are simple; no torque is required to set the anchor.	Typically designed for static loads and not used with reciprocating engines, motors or in situations where vibrations are present.
Sleeve Anchor Universal anchor for light- to medium-duty applications. Multiple head designs fit many applications and can be installed in masonry.	A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If re-assembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or be detached from the expansion cone, requiring anchor replacement. These conditions are not visible.

Internally Threaded	
Description	Warning
Internally Threaded Undercut Anchor Used in heavy-duty applica-tions. Typically come in two types: self-undercutting and those using a specialized undercutting drill bit. Anchors have internal threads. Shallow embedment and small edge distances and spacing are possible.	May require special tools and specific drill bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.
Shell Anchor Flush-mount or sub-surface internally threaded anchor for medium- to light-duty applications. Comes in fractional and metric sizes and is available in a variety of materials.	A special setting tool is required and must be supplied by the anchor manufacturer. The setting tool is designed for each anchor size and style.
Others Similar to the wedge concrete anchor and used in heavy- to light-duty applications. Many configurations are available to fit most applications. Made from a variety of materials.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.

Anchor Selection Guide

Light Duty Fastenings	
Description	Warning
Drive Pin (nail) Anchors (metal and plastic) Light-duty anchor with fast and easy installation in many substrates.	Use only for static loads. Typically not used in overhead applications. **DO NOT USE FOR SEISMIC RESTRAINT**
Concrete Screws Medium- to Light-Duty A variety of lengths and diameters are available. Often used for temporary anchorage.	Typically not used in situations where extensive vibrations are present. Requires the use of a special drill bit (some metric) supplied by the anchor manufacturer.
Special Style Head Wedge (ring) anchor Wedge anchor with integrated connection (head) designed for tie wires or suspended ceilings.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.
Single and Double Expansion Shields Multi-purpose anchor used in concrete, Concrete Masonry Unit (CMU), brick, or stone. This anchor distributes fairly even pressure making its use popular in CMU, brick, and natural stone. Typically use in conjunction with machine bolts, which can be removed and replaced.	Anchor material is malleable and the threads can be stripped. **DO NOT USE FOR SEISMIC RESTRAINT**

Light Duty Fastenings (cont.)	
Description	Warning
Lead Expansion Anchors Similar to expansion shields, but typically considered light-duty. Many can be used with a variety of screws or bolts. Quick and simple to install. Can be used in concrete, CMU, brick, or stone.	Anchor material is malleable and the threads can be stripped. Anchor should not be used in any applications. **DO NOT USE FOR SEISMIC RESTRAINT**
Toggle or "Molly"-type Anchors Light- to medium-duty anchor with easy installation in many substrates. No drilling is required for some anchor types or in some substrates. Some anchors are supplied with bolts or screws. Anchors are made from variety of materials and colors including plastic, zinc alloys, and steel.	May require a large hole. Anchor may or may not be reusable if the bolt is removed. Severe damage to the substrate can result if these anchors are removed after installation.

GLOSSARY

A

Adhesive anchor – An anchor designed to bond directly to concrete within a pre-drilled hole using epoxy or other adhesive.

Anchor – A device for connecting equipment and attachments to the building structure.

Attachments – Support systems used to connect equipment, pipe, conduit, or ductwork to the building.

Attachment type – Use of attachments to floors, walls, roofs, ceilings, and vibration isolators.

B

Bar joist – Ceiling joists supporting intermediate floors or roof made from steel angles and steel bars.

Base plate – A steel plate used for support and anchorage of an angle support or vibration isolator.

Bed joint – A horizontal seam in a brick or concrete block wall. Also see **Head joint**.

Bolt diameter – Thickness or width of the outside of the threaded portion of the bolt.

BTUH – The heating and cooling capacities of equipment in British Thermal Units per Hour.

Building structure – Steel, concrete, masonry and wood members or surfaces that transfer the weight of the building and equipment to the ground.

Bumpers – Angles or other steel shapes with elastomeric padding rigidly mounted to the building structure in a pattern around the equipment base to limit horizontal movement.

Busbars – A conducting bar (usually made of copper) that carries currents to various electric circuits.

C

Cabinet – An enclosure designed for surface mounting or flush mounting that houses controls and electrical components.

Cable brace – A steel cable designed for use as a seismic sway brace for suspended equipment, piping, ductwork, or raceways. Also see **Pre-stretched cable.**

Cant strip – A material used to fill voids in roof flashing.

Cantilevered – A support member connected at one end and unsupported at the other end.

Cast-in-place – A steel shape embedded into concrete.

Cast-in-place anchor – A headed steel bolt or J-bolt set within a concrete form before concrete is poured.

Cold joint – An edge between two concrete surfaces.

Construction documents – Drawings, specifications, and manufacturer's instructions that define the scope of a project and provide detailed information to seismically restrain the equipment, piping, ductwork, or raceways.

Counter flashing – A light-gauge sheet metal folded support or equipment frame to shed water or snow onto the roof.

Curb – Raised or enclosed framework that supports equipment.

Cure – To gain internal strength over time to withstand external forces.

Cure time – The total time it takes for the material to be at an absolute full load capacity.

D

Differential movement – The movement between two objects or surfaces.

E

Edge distance – The distance between a concrete anchor and the edge of a concrete surface or concrete cold joint.

Elastomeric – A material with flexibility in all directions that will return to its original shape if removed from its environment.

Embedded – Fixed firmly in the surrounding material.

Embedment – How far a post-installed anchor is inserted into a hole in concrete or wood after the anchor is set in place and torqued.

Embedment depth – See **Embedment**.

Enclosure – A case or housing to protect electrical components.

Equipment – Any mechanical or electrical component.

Expansion anchor – A post-installed anchor that uses some form of wedge or shell held against the edge of a drilled hole with friction.

F

Ferrule – A small metal tube that can be crimped around steel cables.

Fillet weld – A weld between two pieces of steel where the welded surfaces are at right angles.

Flashing – Metal, asphalt, or elastomeric material with one or more layers surrounding a roof penetration specifically designed to weatherproof the building.

Flexible connector – A connector designed to allow slight movement between a piece of equipment, component, or system and another system in the amount of relative movement in the event of an earthquake.

Flexible mounted equipment – A piece of equipment supported on or from a vibration isolator.

G

Gel time – A specified amount of time for an adhesive to form a jelly-like substance with strength to hold its own weight or the weight of a light steel anchor.

Grommet – A rubber or elastomeric bushing-shaped ring that may be used in restrained springs, snubbers, or with bolts to provide a cushioned or flexible connection.

Groove joint – A mechanical connection between two pipe sections using a tongue-and-groove configuration and elastomeric gasket.

H

Hand tight – The force applied by hand to bring two or more materials together without a space and without the use of tools.

Head joint – A vertical joint between two concrete blocks in a block wall or two bricks in a brick wall. Also see **Bed joint**.

Headed stud – A large bolt with a threaded shaft and a hexagonal shaped bolt head typically used for embedment into concrete surfaces or in-filled concrete walls.

Height-saving bracket – A bracket used to accommodate the height of spring isolators without raising the equipment base more than a few inches.

Housed spring – A spring isolator with steel guides usually separated by an elastomeric sheet located on two opposite sides of the spring.

Housekeeping pad – A concrete pad under equipment that raises the elevation of the equipment above the building structure or structural slab. Also called plinths.

I

Inertia base – A heavily weighted base, usually made of concrete, that weighs more than the equipment it supports.

In-filled block – A concrete block wall whose cells are reinforced with rebar and filled with a sand-grout mixture.

Inlet – The location or connection to equipment where a substance such as water or air enters the equipment.

Isolation curb – See **Manufactured isolation curb.**

Isolators – See **Vibration isolators.**

L

Leveling stanchions – See **Stanchions.**

Load path – Seismic support of equipment and internal components that can be traced though connections and support steel to the building structure.

Load transfer angles – Angles bolted to equipment and to the building structure, transferring the weight and earthquake load through the angles to the building structure.

Longitudinal brace – A brace that restrains pipes, ducts, or raceways parallel to the longitudinal direction of the pipe, duct run, or raceway.

M

Manufactured isolation curb – A factory-built curb designed to attach equipment to a roof and containing vibration isolators, which allow for slight movement of the equipment.

N

No-hub pipe – Pipe designed for connections that do not interlock or permanently join.

Nominal diameter – The diameter across the outer-most edges of a bolt or threaded rod.

O

Open spring – A spring isolator with a bolt attachment at the top of the spring for connecting to equipment without any horizontal support.

Outlet – The location or connection to equipment where a substance such as water or air exits the equipment.

P

Plenum – An enclosed space usually made from galvanized sheet steel allowing airflow from one duct system to another; the entrance to and/or exit from a fan or air handling unit.

Plug weld – The weld of a plate or base plate to another metal surface where a plate is perforated with one or more holes, which are then filled with the weld filler material.

Point load – Weight and seismic forces that are focused to a single point connection to the building structure.

Post and beam – An elevated structure usually made from beams resting on posts or stanchions connected to the building structure.

Post-installed anchor – Anchors installed after the building structure is completed.

Post-tension building – A concrete building structure surface with internal steel cables that are stretched and restrained to permanently compress the concrete surface.

Pre-manufactured curb – A sheet metal curb manufactured at a factory and sent to the job site.

Pre-stretched cable – Cable that is stretched after it is manufactured.

R

Raceway – A channel (conduit or open raceway) designed to hold wires and cables or busbars.

Rated spring deflection – The dimension a spring will compress when the weight of equipment is applied.

Rehabilitation – A new installation within an existing facility.

Restrained spring – A vibration isolator containing a spring enclosed in a welded or bolted steel housing that limits the movement of the spring equipment attachment in all directions.

Rigid-mounted equipment – Equipment solidly braced or bolted directly to the building structure without vibration isolation.

S

Screen – A tube of steel wire mesh used as an adhesive anchor for anchoring to block or brick walls.

Seismic cable – A steel or stainless steel braided rope.

Seismic restraint device – An attachment device designed to restrict movement of equipment during an earthquake.

Seismic restraint device submittals – Documents created by contractors or vendors describing the means and methods for installing seismic restraint devices and submitted for design approval.

Seismic rod clamp – A clamping device for attaching rod stiffeners to a vertical threaded rod.

Self-drilling – A special type of concrete shell anchor with cutting teeth for drilling into concrete.

Self-tapping – Either a sheet metal screw with blades on the end (similar to a drill bit), allowing the screw to drill a hole and embed itself into a steel shape, or a concrete screw with a point and specially designed threads allowing the screw to grip the concrete and embed itself into the concrete.

Set time – The specific time required for material to harden when a light load may be applied.

Shallow concrete anchor – Any anchor with an embedment depth measuring less than 1/8th of its diameter.

Sheet metal curb – A square or rectangular box made from galvanized steel sheets used to connect equipment to a roof.

Sheet steel housings – Sheet steel that fully or partially encloses a piece of equipment.

Shim – A thin wedge of material used to fill a space.

Snubber – A seismic restraint device used on isolated systems with an air gap and elastomeric bushing or oil-filled hydraulic cylinder (shock absorber) restricting the rapid motion of a pipe.

Snug tight – The force applied by hand to bring two or more materials together without a space and without the use of tools.

Solid brace – A steel angle or strut channel designed for use as a seismic sway brace for suspended equipment, piping, ductwork, or raceways.

Spring-isolated – See **Vibration-isolated.**

Stanchions – Columns or short structural steel shapes placed vertically that connect to equipment bases or horizontal structural steel frames to provide equipment support.

Structural steel shapes – A manufactured steel component in a variety of shapes.

Strut – A manufactured steel shape in various U-shaped patterns and sizes.

Strut frame – Steel framing made from strut members that act as a support to transfer the equipment weight to the building structure. See **Strut**.

Sway brace – Solid braces or cable braces that provide seismic restraint.

T

Tendons – Steel cables used in post-tension buildings. Also see **Post-tension building.**

Thimble – A metal spacer used on a cable to protect it from being bent and damaged.

Transverse brace – A brace that restrains pipes, ducts, or raceways perpendicular to the longitudinal direction.

Toe of the weld – The edge of a fillet weld.

Torque – A turning force around a bolt applied by twisting a bolt head or nut so the components will not separate.

Turn-of-the-nut method – A process to properly torque a bolt without a special tool like a calibrated torque wrench.

V

VAV boxes – A terminal unit or plenum with an internal damper and control actuator that can vary airflow quantities.

Vibration-isolated – Allows flexible motion between equipment, piping, ductwork, or raceways and the building structure.

Vibration isolators – Components containing springs used to separate equipment from the building structure.

W

Web – A thin metal strip in a structural steel shape.

Weld base material – The material composition of an item being welded.

INDEX

A-coil 16-17, 139, 140
air compressor 4-5
air conditioning unit 6-7, 139, 140
air handling unit 8-10
air separator 11
anchor 96-102, 149
- adhesive 96-97, 100, 101, 106, 109-111, 142-143, 149
- cast-in-place 35, 63, 96, 103, 104, 150
- concrete 112
- concrete screw 106, 111
- drywall 112
- embedded plates 36, 96, 119
- externally threaded 144-145
- general 96
- inserting 100-101, 109
- internally threaded 146
- lag bolts 96, 104, 106, 108, 112
- light-duty fastenings 147
- masonry and drywall 96, 106-113
- non-adhesive 97
- post-installed 63, 96
- powder-actuated 141
- sheet metal screw 106, 108, 112, 114
- shell 96, 99, 101
- sizes for equipment less than 400 pounds 121-123
- sleeve 96, 99, 106
- steel bolt 96, 114-115
- through-bolt 106
- toggle bolt 106, 111-112
- umbrella 106, 110-111
- undercut 96, 99, 101
- wedge 96, 99, 106
- welding 119-120

anchor selection guide 141-148
angle 36-40, 45, 68-70, 73-74, 90-92, 93, 130-132
attachment types 32-95, 149
- rigid floor-mounted/pad-mounted 32-47
- roof-mounted 48-62
- suspended 62-76
- vibration-isolated/floor-mounted 77-87
- wall-mounted 88-95

bar joist 65, 149
base 79
inertia 41, 85, 152
plate 91, 149
round 36, 39
block walls 107, 109, 110, 111, 113
boiler 12-13
bracket 62, 68, 70, 76, 88, 95, 102, 118, 125
bumpers 41-42, 77, 79, 149

cable 62-68, 70-72, 76, 124-129
attach using:
bolts with center holes 125-126
ferrule clamps 126-127
wire rope grips 128-129
chain 95
chiller 14-15
coil 9, 16-17
concrete
joint 41-42
pouring 138
slab 65
condenser, condensing unit 18-19, 139
control panels 130-134
cooling tower 20-21
curb 58-59, 150
built-up 51-56
isolation 58-59
pre-manufactured 51-56
curing 110, 113, 138, 150

dowel 137
duct-mounted coil 16-17, 73
duct silencer 30-31
ductwork 36, 40, 89, 93

embedment depth 98-99, 105, 112
end-suction pump
equipment 4-31
less than 150 pounds 45, 73
less than 400 pounds 45, 121-123
setting/moving in place 35, 40, 44, 81, 84, 86, 89, 93, 103, 105, 113, 151
typical 5, 7, 10, 11, 13, 15, 17
evaporative cooler 20-21

Index

fan 22-23
fan-coil unit 30-31
ferrule clamps 126-127, 151
flashing 49-50, 55, 57, 58, 61, 151
floor-mounted 32-47, 77-87
fluid cooler 20-21
frame 46-47, 50-51, 57, 58-59, 60-61, 94, 133-134
furnace 12-13, 139

gap 102
gas cylinder 28-29, 47, 95
grout 102, 108, 113

head joint 107
heater 24-25, 75
heat exchanger 16-17
heat pump 6-7
hole 97-100, 107-109, 115
cleaning 100, 109
clearance 104
drilling 98-99, 107-108, 115, 125, 138
lead 105
oversized, repair of 35
housekeeping pad 135-138, 152
humidifier 12-13

masonry and drywall anchors (see anchors)

pad-mounted (see rigid floor-mounted/pad-mounted attachment)
piping 36, 40, 89, 93
plate 130-132
post and beam 48-51, 58-59, 153
pump 26-27, 87

raceways 36, 40, 89, 93, 154
raised floor 43-44
rebar 99
residential equipment 139-140
rigid floor-mounted/pad-mounted attachment 32-47
at a single point 45-46
beneath a raised floor 43-44
directly to the floor/pad 32-36
using a strut and plate frame 46-47
using additional structural steel shapes 36-40
using bumpers to restrict horizontal movement 41-42

rods 62-68, 70-72, 75, 76, 93, 116-117, 118
roof-mounted attachment 48-61
    to a wood frame 57
    using leveling stanchions—post and beam 48-51
    using restrained springs on leveling stanchions 60-61
    using seismic built-up/pre-manufactured curb 51-55
    using seismic pre-manufactured vibration isolation 58-59

screen insert 109
seismic restraint device 2, 154
sheet steel 32, 33, 155
snubber 77-78, 83, 85-86
special cases 124-140
    cables 124-129
    control panels 130-134
    housekeeping pads 135-138
    residential equipment 139-140
spring 77-78
    housed 77
    isolator 84, 86
    open 77, 83-87
    restrained 60-61, 78, 79-82, 154
stanchion 48-51, 58-61, 155
stand 43
steel beam 64
steel bolt connection 114-120
    bolted to a concrete floor 114-115
    bolting two structural shapes together 116
    bolting a threaded rod to steel shapes or strut 116-118
steel shape 36-40, 90-93, 104, 118, 119, 155
strap 91-93
structural framing 32, 34
strut 70, 74, 90, 93, 130-133, 156
stud 92
suspended attachment raised 62-76
    rigid using 4 threaded rods with horizontal cable supports 62-68
    rigid using angle supports 68-70
    isolated using threaded rods and horizontal cable supports 70-72
    double angle attachment—bolted or welded to the bulding 73-74
    double rod attachment—bolted to the building 75-76

tank 28-29, 47
tendons 98, 156
terminal unit 30-31
thimble 129, 156
through-the-wall air conditioner 140
torque 102, 103, 115, 116, 117, 118, 126, 127, 156
turn-of-nut method 115

VAV box 30-31, 73, 156
vibration-isolated/floor-mounted attachment 77-87
    on open springs combined with snubbers 83-87
    on restrained springs 79-82
vibration isolators 93-94, 156

wall-mounted attachment 88-95, 133
    directly to the wall 88-89
    directly to the wall—gas cylinders only 95
    to additional structural shapes attached to the wall 90-93
    vibration-isolated off the wall 93-94
water heater 12-13, 92, 139
webs 107-108, 156
weld 36, 40, 50, 55, 61, 119-120
wire rope grips 128-129
wood beam 64
wood frame 57

“Z” bar 137

APPENDIX 3

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INSTALLING SEISMIC RESTRAINTS FOR ELECTRICAL EQUIPMENT

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INSTALLING SEISMIC RESTRAINTS FOR ELECTRICAL EQUIPMENT

January 2004

FEMA

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Vibration Isolation and Seismic Control Manufacturers Association

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Developed by the Vibration Isolation and Seismic Control Manufacturers Association under a cooperative agreement between the Federal Emergency Management Agency and the American Society of Civil Engineers

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TABLE OF CONTENTS

INTRODUCTION 1

EQUIPMENT 4

- Automatic Transfer Switches 4
- Control Panels 6
- Generators 8
- Lighting 10
- Load Centers and Panelboards 12
- Low Voltage: Substations, Capacitor Banks, Switchboards, and Switchgears 14
- Medium to High Voltage: Switchgears, Circuit Interrupters, Substation Circuit Breakers, and Walk-in Enclosures 16
- Meters and Disconnects 18
- Motor Control Centers and Variable Frequency Drives 20
- Multi-media Racks 22
- Transformers 24
- Uninterruptable Power Supplies and Battery Racks 26
- Unit Heaters and Tanks 28

RACEWAYS/CONDUITS/CABLE TRAYS 30

ATTACHMENT TYPES 51

- Rigid Floor-mounted/Pad-mounted Attachments 51
- Roof-mounted Attachments 65
- Suspended Attachments 71
- Vibration-isolated/Floor-mounted Attachments 87
- Wall-mounted Attachments 98

ANCHORS 104

- General Anchors 104
- Cast-in-place Anchors 111
- Lag Bolts 112
- Masonry and Drywall Anchors 114
- Power-Actuated Anchors 122
- Steel Bolt Connections 123
- Welding 128
- Anchor Sizes for Equipment Weighing Less Than 400 Pounds 130

SPECIAL CASES **133**
Cables 133
Control Panels 139
Housekeeping Pads 144
Lighting 148

ANCHOR SELECTION GUIDE **151**

ELECTRICAL DANGER INSTRUCTION CHART **160**

GLOSSARY **162**

INDEX **171**

INTRODUCTION

This guide shows equipment installers how to attach electrical equipment to a building to minimize earthquake damage. Many attachment examples are presented, including anchors and the use of special devices called *seismic restraint devices.*

Seismic restraint devices include vibration isolation systems, cable or strut suspension systems, roof attachment systems, and steel shapes.

An electrical danger instruction chart is provided (page 160) as a basic guideline. Follow all safety requirements as required by code, including those listed below:

- Printed instructions shipped with the equipment.
- Instructions in construction drawings and specifications. Use approved construction documents.
- Code-required, industry-accepted practices.
- Electrical safety guidelines and practices.
- Orders from your supervisor.
- Seismic restraint device submittals.

This guide does not replace any of the above referenced materials.

Please note that this guide does not cover:

- Fire protection sprinkler, smoke and fire stops, or fire detection governed by local codes and the National Fire Protection Association.
- Framing design required to elevate equipment above the floor.

If you have questions about any information in this guide, check with your supervisor.

This guide contains the following sections:

- *Equipment:* Arranged according to different kinds of electrical equipment such as computer racks, control panels, lighting, substations, etc.
- *Raceways/Conduits/Cable Trays:* Covers the different ways to install raceways, conduits, and cable trays.
- *Attachment Types:* Gives instructions on installing equipment in different arrangements known as *attachment types.*
- *Anchors:* Shows many different types of anchors used to connect equipment to a building.
- *Special Cases:* Covers housekeeping pads, and other unique applications.

To use this guide:

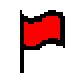
1. Use the Table of Contents to find the Equipment section that best represents the equipment you are installing.
2. Using the table (see example below) in the Equipment section, find the:
   - type of equipment you are installing in column 1
   - method of installing the equipment in column 2
   - attachment type in column 3.

column 1	column 2	column 3
Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Connected to angles mounted to the floor	Rigid with angles *Go to page 53*

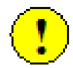
3. Turn to the page referenced in column 3 for the equipment/attachment type you have selected. If you are not sure which attachment type is correct, ask your supervisor.
4. Follow the instructions for the attachment type you have selected. These instructions will refer you to the correct anchor section so you can make the connection to the building structure.

NOTE: All instructions in this guide are arranged in order using numbered steps. Please follow every step in the sequence shown.

Special precautions are marked:



A flag means you should take special care before continuing. Read all the information next to a flag before attaching the equipment.



A warning sign means you can cause serious damage to the building, the device, or the equipment if you do not follow the instructions exactly.

A book means you should refer to the manufacturer's printed instructions before continuing.

Note that a Glossary and an Index are also available to facilitate use of this guide.

EQUIPMENT

Automatic Transfer Switches

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 1: Automatic transfer switch (surface wall-mounted).

Figure 2: Automatic transfer switch (floor-mounted).

Figure 3: Automatic transfer and bypass-isolation switch (floor-mounted).

Figure 4: Service entrance with transfer switch (floor-mounted).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*

Table 1: Automatic transfer switch installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Control Panels

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 5: Control panel (flush wall-mounted).

Figure 6: Control panel (surface floor-mounted).

Figure 7: Control panel (floor-mounted).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	On a raised floor	Raised floor *Go to page 61*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
	Strut and Plate framing support systems	Special Cases: Control Panels *Go to page 139*
	Flush-mounted	Follow manufacturer's instructions
	Connected to companion equipment	Follow manufacturer's instructions

Table 2: Control panel installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Generators

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 8: Generator controls (equipment-mounted).

Figure 9: Housed generator (floor-mounted).

Figure 10: Generator with weatherproof housing (pad-mounted).

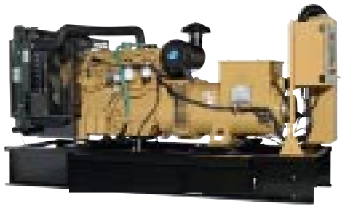


Figure 11: Generator with radiator (pad-mounted). *Radiator may be remotely mounted.*

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of generator	Mounted directly to the floor or pad	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Vibration-isolated	Vibration-isolated/ floor-mounted *Go to page 87*
	Roof-mounted or vibration-isolated on a roof	Roof-mounted *Go to page 65*
Generator controls	Connected to equipment	Follow manufacturer's instructions

Table 3: Generator installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

For generator fuel tanks, see the Unit Heaters and Tanks equipment section on page 28.

Refer to approved construction documents for installation requirements for exhaust and muffler noise control.

Lighting

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

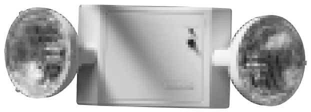


Figure 12: Battery powered light.

Figure 13: Exit light/lighted signs.

Figure 14: Flush-mounted light.

Figure 15: Lay-in light.

Figure 16: Pendant light.

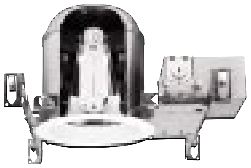


Figure 17: Recessed light.

Figure 18: Wall-mounted light.

Figure 19: Industrial light.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Battery powered light, exit light, or flush-mounted light	Directly attached to any surface using attachment instructions for wall-mounted equipment	Wall-mounted *Go to page 98*
Lay-in light and flush-mounted light	Installed in T-bar ceilings	Special cases: Lighting *Go to page 149*
Pendant light	Directly attached to building stucture	Special cases: Lighting *Go to page 150*
Recessed light and industrial light	Directly attached to building structure	Follow manufacturer's instructions
Surface-mounted light	Surface-mounted to horizontal building structure surface. Ceilings must have capacity to transfer load to buiilding structure	Use attachment instructions for wall-mounted equipment *Go to page 98*
Chandeliers or chain-supported equipment	Suspended from the building structure	Suspended with chain *Go to page 86*

Table 4: Lighting installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Load Centers and Panelboards

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 20: Load center (flush wall-mounted).

Figure 21: Load center (surface wall-mounted).

Figure 22: Panelboard (flush wall-mounted).

Figure 23: Panelboard (surface wall-mounted).

Figure 24: Panelboard (floor-mounted).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
	Flush-mounted	Follow manufacturer's instructions

Table 5: Load center and panelboard installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Low Voltage: Substations, Capacitor Banks, Switchboards, and Switchgears

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 25: Substation (floor-mounted).

Figure 26: Capacitor bank (floor-mounted).

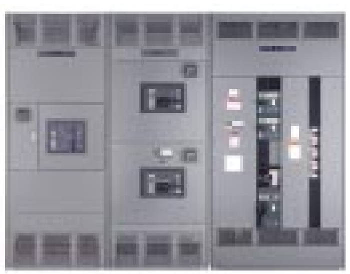


Figure 27: Low voltage switchboard (floor-mounted).

Figure 28: Low voltage switchboard (floor-mounted).

Figure 29: Low voltage switchgear (floor-mounted).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Floor-mounted with bumpers	Floor-mounted *Go to page 60*
	Roof-mounted or vibration-isolated on a roof	Roof-mounted *Go to page 65*
	Vibration-isolated	Vibration-isolated/ floor-mounted *Go to page 87*

Table 6: Low voltage: substation, capacitor bank, switchboard, and switchgear installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Medium to High Voltage: Switchgears, Circuit Interrupters, Substation Circuit Breakers, and Walk-in Enclosures

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 30: Medium voltage arc-resistant switchgear (floor-mounted).

Figure 31: High voltage circuit interrupter (floor-mounted).

Figure 32: Substation circuit breaker.

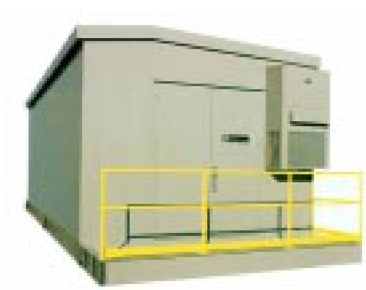


Figure 33: Walk-in enclosure.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Floor-mounted with bumpers	Floor-mounted *Go to page 60*
	Roof-mounted or vibration-isolated on a roof	Roof-mounted *Go to page 65*
	Vibration-isolated	Vibration-isolated/ floor-mounted *Go to page 87*

Table 7: Medium to high voltage: switchgear, circuit interrupter, substation circuit breaker, and walk-in enclosure installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Meters and Disconnects

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 34: Meter center (floor-mounted).

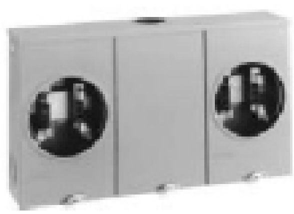


Figure 35: Meter center (surface-mounted).

Figure 36: Safety switch (surface-mounted).

Figure 37: Double throw safety switch (surface-mounted).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
	Connected to companion equipment	Follow manufacturer's instructions

Table 8: Meter and disconnect installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Motor Control Centers and Variable Frequency Drives

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 38: Low voltage motor control center (floor-mounted).

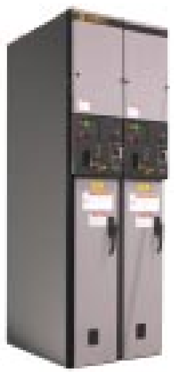


Figure 39: Medium voltage motor control center (floor-mounted).

Figure 40: Enclosed motor (wall-mounted).

Figure 41: Variable frequency drive (wall-mounted).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
	Vibration-isolated	Floor-mounted *Go to page 87*
		Wall-mounted with angles *Go to page 102*
	Connected to companion equipment	Follow manufacturer's instructions

Table 9: Motor control center and variable frequency drive installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Multi-media Racks

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 42: Computer rack with or without rollers (floor-mounted).

Figure 43: Equipment rack with or without rollers (floor-mounted).

Figure 44: Open rack (floor-mounted).

Figure 45: Media equipment (wall-mounted).

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
	Connected to companion equipment	Follow manufacturer's instructions

Table 10: Multi-media rack installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Rollers must be constructed to withstand additional forces created by earthquakes.

Transformers

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 46: Dry-type transformer (wall-mounted).

Figure 47: Dry-type transformer (floor-mounted).

Figure 48: Substation dry-type transformer.

Figure 49: Substation liquid-filled transformer.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	Using bumpers	Floor-mounted with bumpers *Go to page 60*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
	Mounted to the wall with vibration isolation	Wall-mounted, vibration-isolated *Go to page 102*
	Vibration-isolated	Vibration-isolated/ floor-mounted *Go to page 87*
	Roof-mounted	Roof-mounted *Go to page 65*

Table 11: Transformer installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Uninterruptable Power Supplies and Battery Racks

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

Figure 50: UPS in multi-media rack.

Figure 51: UPS (wall-mounted).

Figure 52: UPS (floor-mounted).

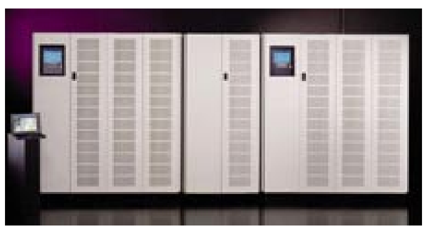


Figure 53: UPS (floor-mounted).

Figure 54: Open battery rack.

Figure 55: Cabinet battery rack.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Mounted directly to the floor	Rigid *Go to page 51*
	Connected to angles mounted to the floor	Rigid with angles *Go to page 55*
	On a raised floor	On a raised floor *Go to page 61*
	Directly to the wall	Wall-mounted *Go to page 98*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
	Mounted to the wall with vibration isolation	Wall-mounted, vibration-isolated *Go to page 102*
	Vibration-isolated	Vibration-isolated/ floor-mounted *Go to page 87*
	Roof-mounted	Roof-mounted *Go to page 65*

Table 12: Uninterruptable power supply and battery rack installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

Batteries must be restrained in the racks. See manufacturer's instructions.

Follow the manufacturer's instructions for field-erected battery racks.

Unit Heaters and Tanks

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the equipment

This manual covers unit heaters suspended from the building structure and floor-mounted tanks in service with generators. Other tank configurations are covered in other manuals.

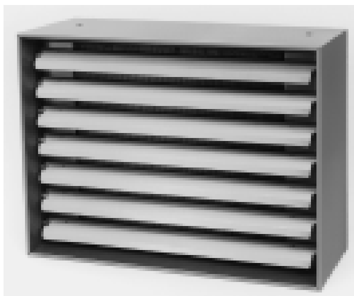


Figure 56: Electric unit heater.

Figure 57: Fuel oil day tank.

Step 2: Select the type of attachment

Using the following table, select how the equipment is to be installed, select the attachment type that best matches the installation you have selected, then turn to the page under the attachment type.

Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any unit heater	Suspended from the building structure with rods and cables	Rigid with rods and cables *Go to page 71*
	Suspended from the building structure with angles	Rigid with angles *Go to page 78*
	Suspended from the building structure with isolators, rods and cables	Vibration-isolated/ suspended *Go to page 81*
	Mounted to the wall with angles	Wall-mounted with angles *Go to page 100*
Relatively thin unit heater	Suspended from the building structure with two rods and cables	Two-point *Go to page 84*
Any tank	Mounted directly to the floor	Rigid *Go to page 51*

Table 13: Unit heater and tank installation types.

Refer to the Electrical Danger Instruction Chart on page 160.

RACEWAYS/CONDUITS/CABLE TRAYS

Electrical raceways include conduits and cable trays.

For post tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers and seismic separation joints.

Each run of conduit or cable tray must have at least one transverse supports at each end of the run and at least one longitudinal support anywhere on the run.

Pre-approved manufacturer's/industry manuals used for installation of conduit supports are required to be on the job site to ensure the correct details are being used.

Do not mix strut and cable bracing systems.

The eight ways to install raceways are:

- Supported from the floor with angles or strut system (page 31).
- Supported from the wall (page 34).
- Suspended using clevis hanger braced at the restraining bolt (page 36).
- Suspended using clevis hanger braced at the hanger rod (page 39).
- Suspended using clevis hanger and four-way cable brace (page 41).
- Suspended using conduit clamps (page 43).
- Suspended with a trapeze support system (page 47).
- Crossing seismic joints (page 50).

Supported from the floor

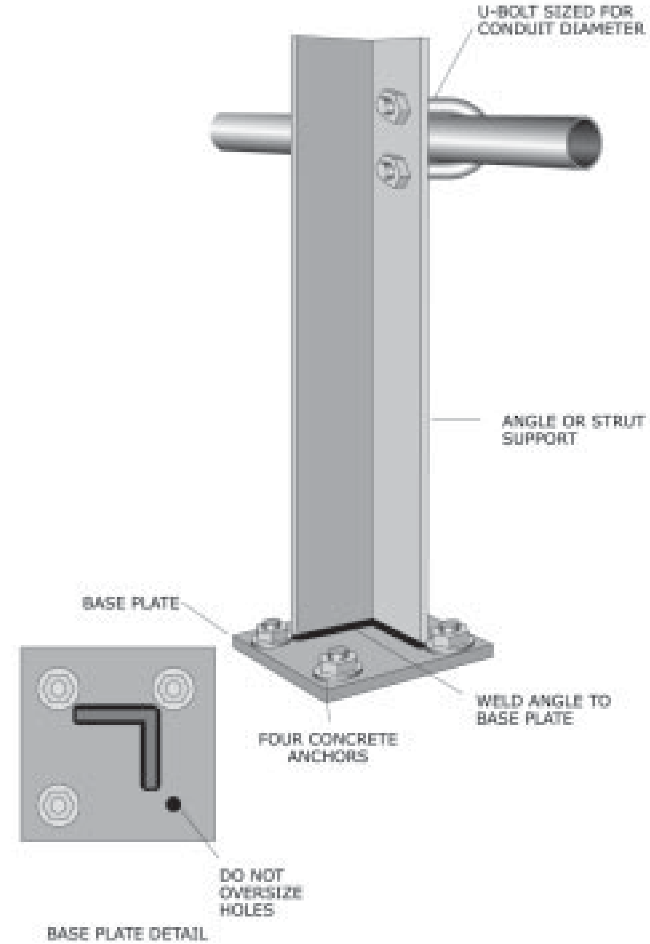
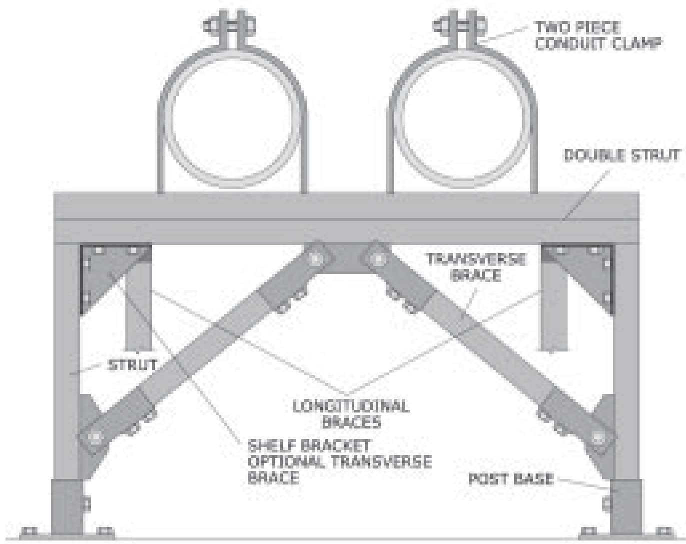
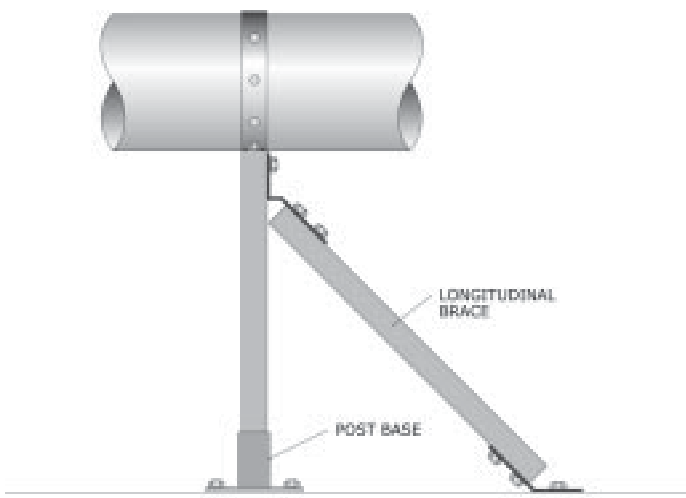


Figure 58: Single vertical support.

Use the instructions on page 35 for installing rigid supports.



Laterally braced raceways/conduit/cable trays



Axially braced raceways/conduit/cable trays

Figure 59: Braced raceways/conduit/cable trays supported from strut.

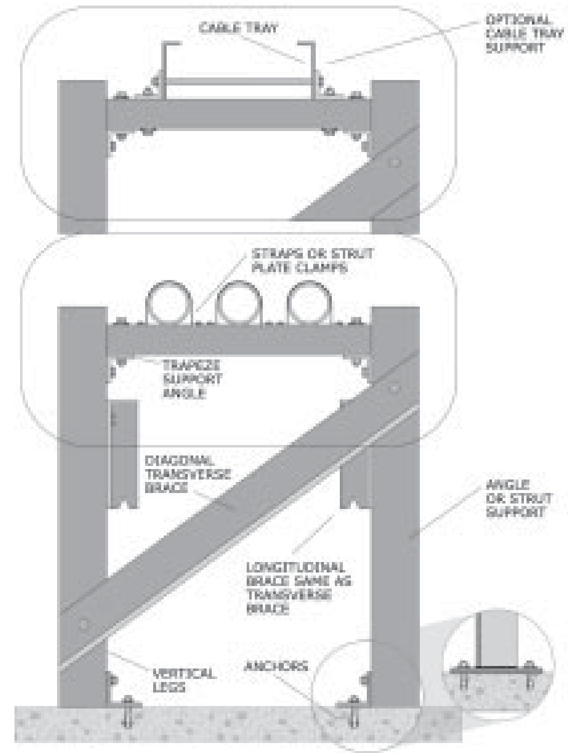


Figure 60: Attachment to a floor with a trapeze support system.

Step 1: Determine dimensions of trapeze support

Match trapeze support with the bottom of the conduit. Ensure that the width of the support allows clearance for installing clamps.

Step 2: Build trapeze support

Step 3: Determine where to drill holes in floor

Coordinate the support base hole locations with the location of any steel reinforcements or tendons.

Building structures must be point load capable. Verify with the appropriate design professional.

Step 4: Install anchors

For instructions on installing anchors, see Anchors (page 104).

Step 5: Run conduit and install conduit clamps

Secure cable tray to strut or angle with one- or two-hole brackets provided with the cable tray, or use two half angles.

END OF ATTACHMENT.

Supported from the wall

The instructions below should also be used for conduit that is surface-mounted on the underside of a building structural slab or rated structural ceiling.

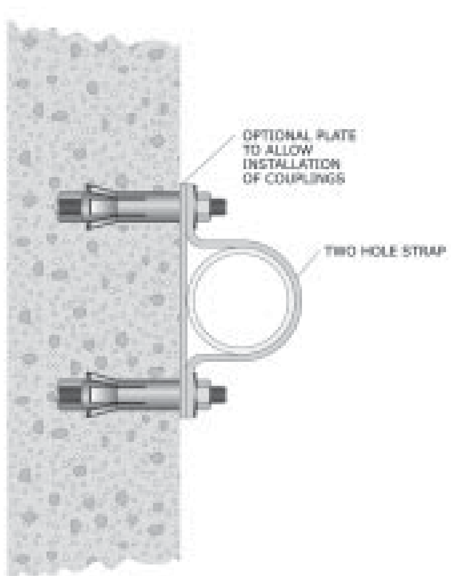


Figure 61: Direct attachment

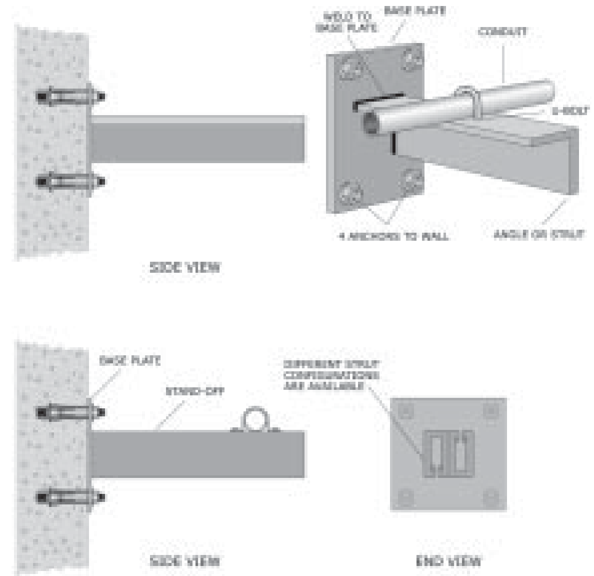


Figure 62: Attach to the wall with angle or strut welded to base plate.

Step 1: Attach support or angles to the wall

For instructions on installing anchors, see Anchors (page 104).

Building structures must be point load capable. Verify with the appropriate design professional.

For drywall attachments, use a strut attachment to the studs as shown in Figure 157 (page 142).

Step 2: Attach conduits to support with straps

The length of standoff as shown on approved construction documents or manufacturer's manuals must be rated for applied conduit weight.

END OF ATTACHMENT.

Suspended using clevis hanger braced at the restraining bolt

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 92 through 98 (pages 71 to 75). For instructions on installing anchors, see Anchors (page 104).

Building structures must be point load capable. Verify with the appropriate design professional.

Step 2: Run raceways or conduits as required by the approved construction documents

Step 3: Attach anchors to the building structure for lateral support restraints

Refer to the pre-approved manufacturer's/ industry manuals for spacing of supports.

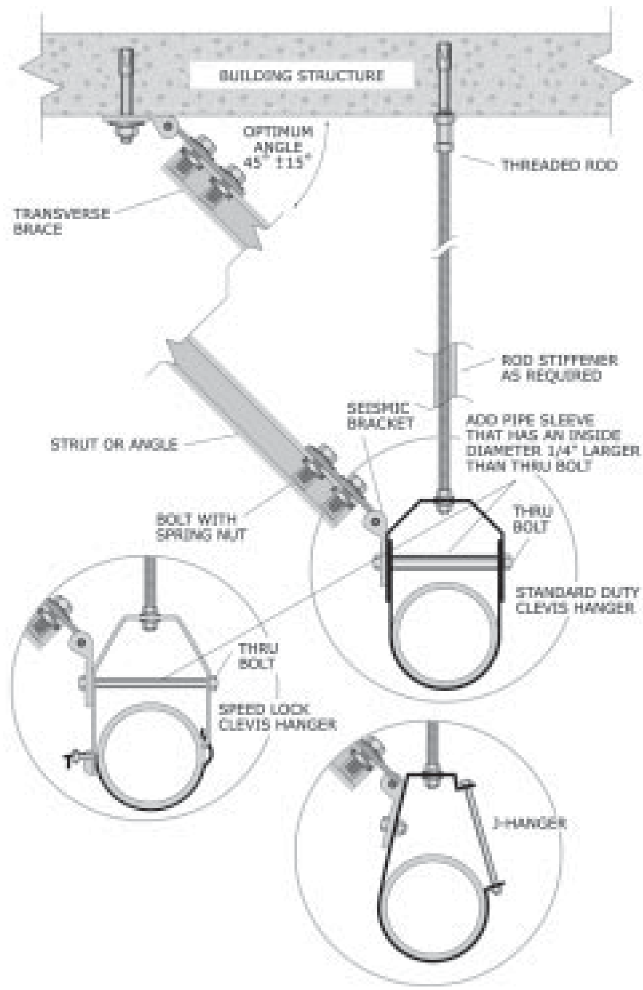


Figure 63: Single clevis hanger support with strut or angle lateral supports at the restraining bolt.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

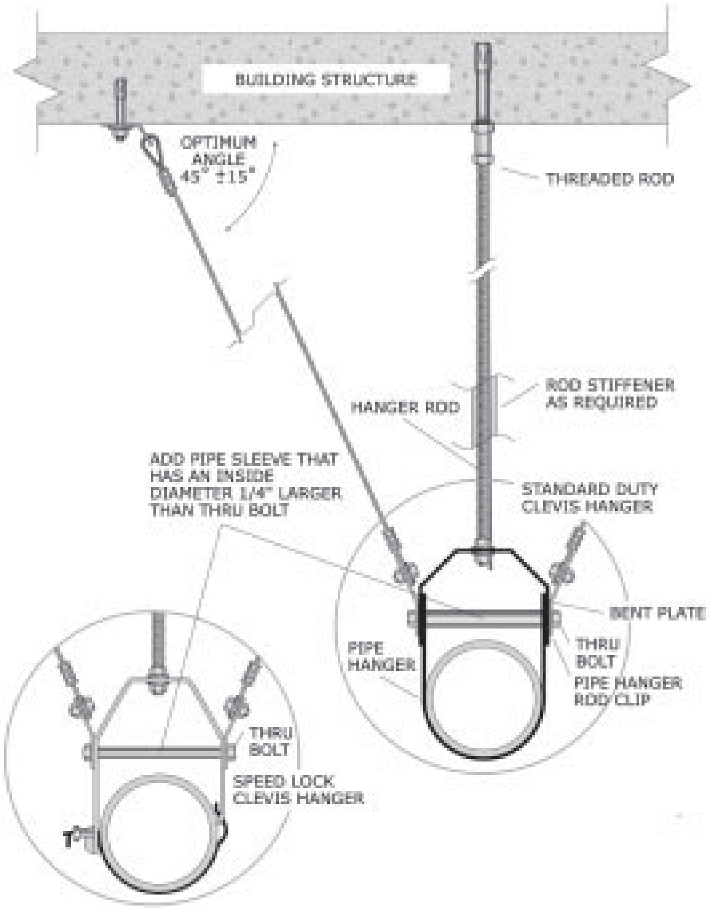


Figure 64: Single clevis hanger support with cable lateral supports at the restraining bolt.

For cable assembly instructions, see Cables (page 133). For details on attaching cable to the building structure, see Figure 100 (page 77). For angle and strut attachment, see Figure 103 (page 79). For instructions on installing anchors, see Anchors (page 104).

Torque bolts per manufacturer's recommendations.

END OF ATTACHMENT.

Suspended using clevis hanger braced at the hanger rod

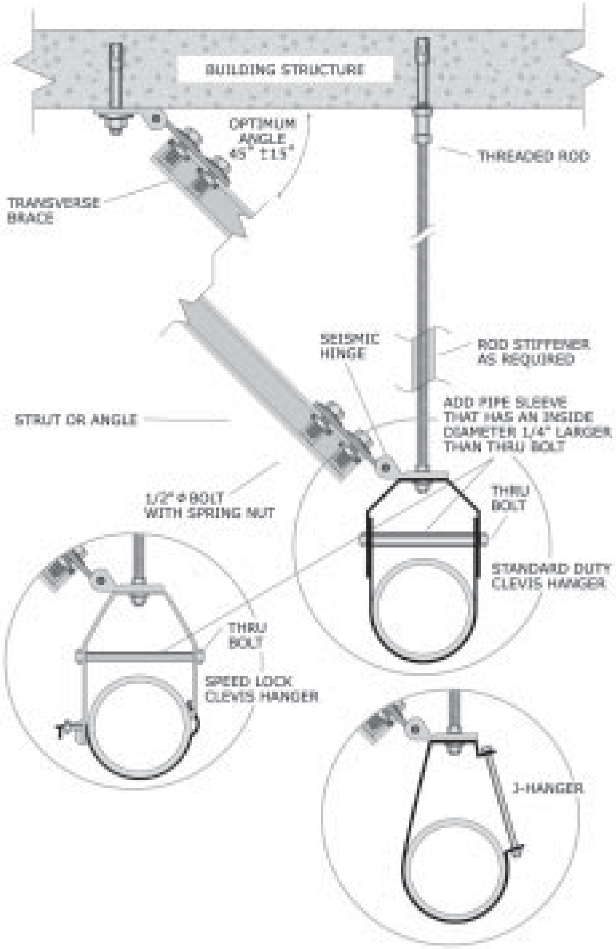


Figure 65: Single clevis hanger support with strut or angle lateral supports at hanger rod.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 92 through 98 (pages 71 to 75). For direct attachment to buidling structure, see Anchors (page 104).

Building structures must be point load capable. Verify with the appropriate design professional.

Step 2: Run conduits as required by the approved construction documents

Step 3: Attach anchors to the building structure for lateral support restraints

For cable assembly instructions, see Cables (page 133). For details on attaching cable to the building structure, see Figure 100 (page 77). For angle and strut attachment, see Figure 103 (page 79). For instructions on installing anchors, see Anchors (page 104).

Step 4: Attach cables to conduit

END OF ATTACHMENT.

Raceways/Conduits/Cable Trays

Suspended using clevis hanger and four-way cable brace

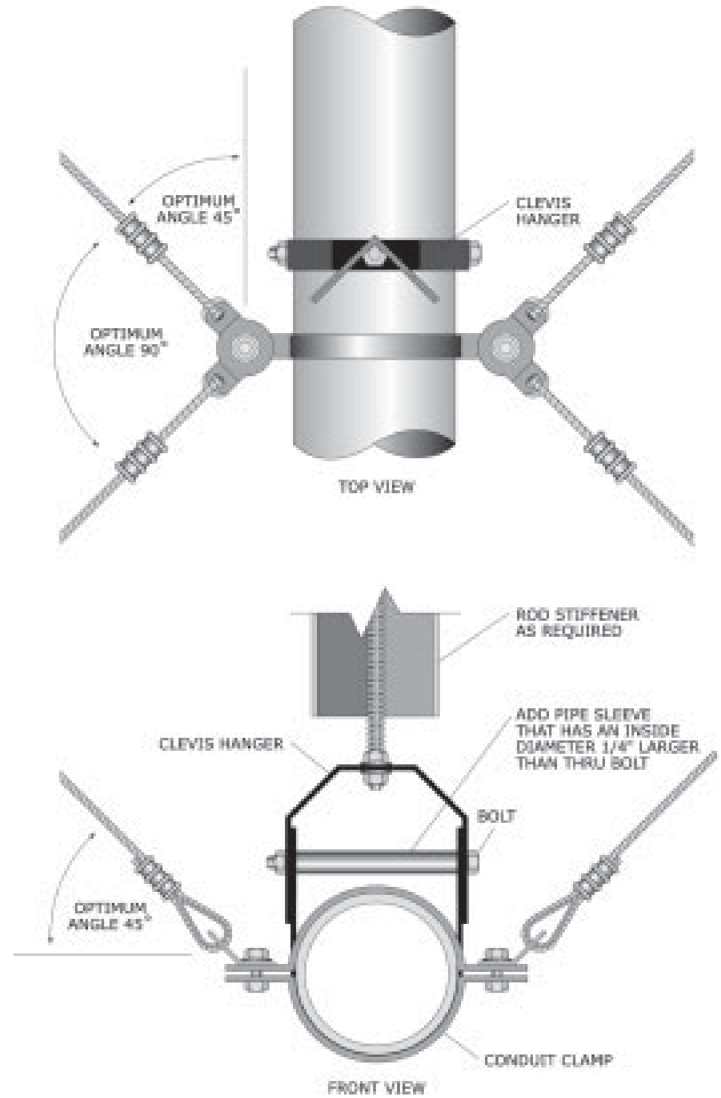


Figure 66: Single clevis hanger with four-way cable brace.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 92 through 98 (pages 71 to 75). For instructions on installing anchors, see Anchors (page 104).

Building structures must be point load capable. Verify with the appropriate design professional.

Step 2: Run conduits as required by the approved construction documents

Step 3: Attach anchors to the building structure for lateral support restraints

For cable assembly instructions, see Cables (page 133). For details on attaching cable to the building structure, see Figure 100 (page 77). For angle and strut attachment, see Figure 103 (page 79). For instructions on installing anchors, see Anchors (page 104).

END OF ATTACHMENT.

Suspended using conduit clamps

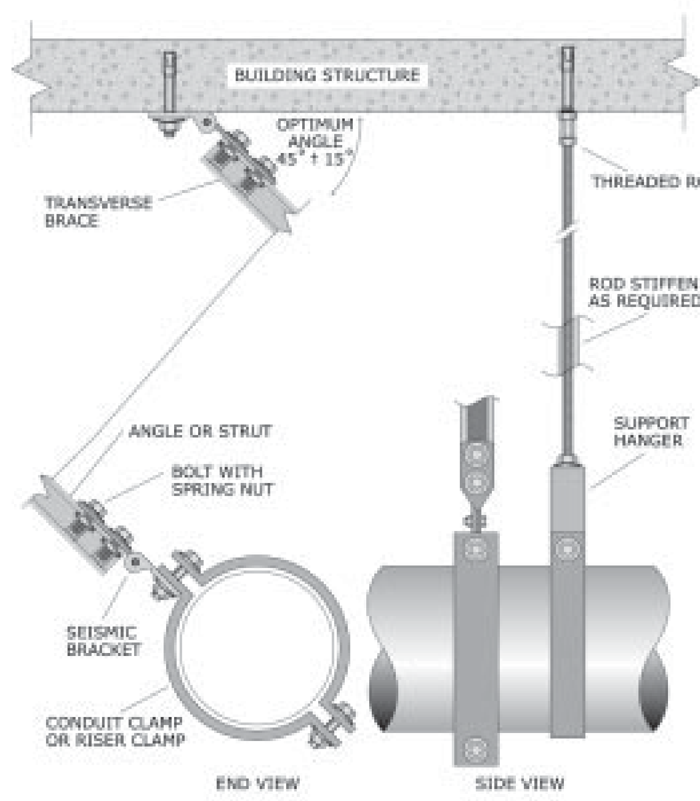


Figure 67: Conduit clamp supports with transverse strut or angle lateral support and hanger rod.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

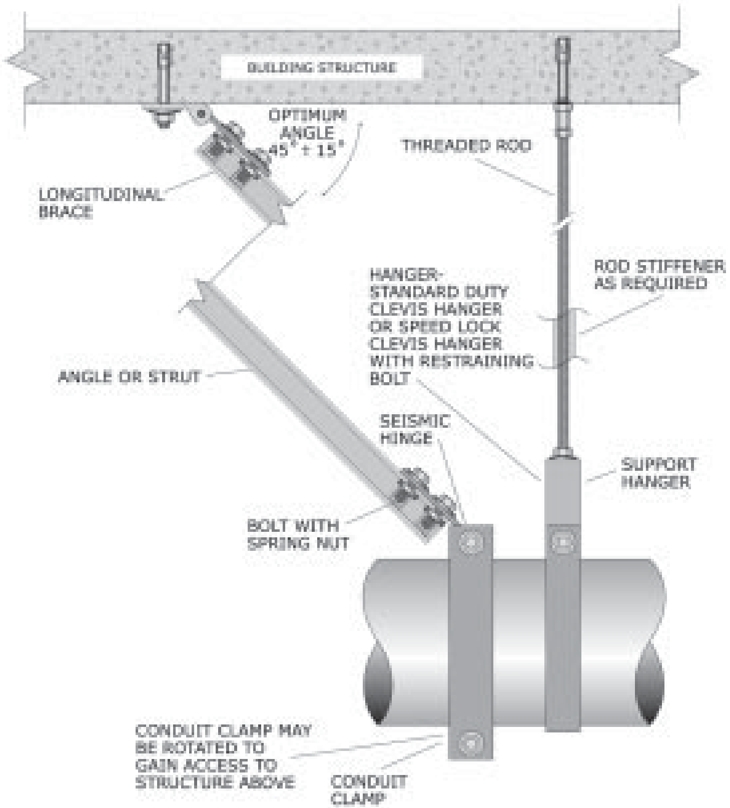
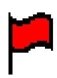


Figure 68: Conduit clamp supports with longitudinal strut or angle lateral support and hanger rod.



Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

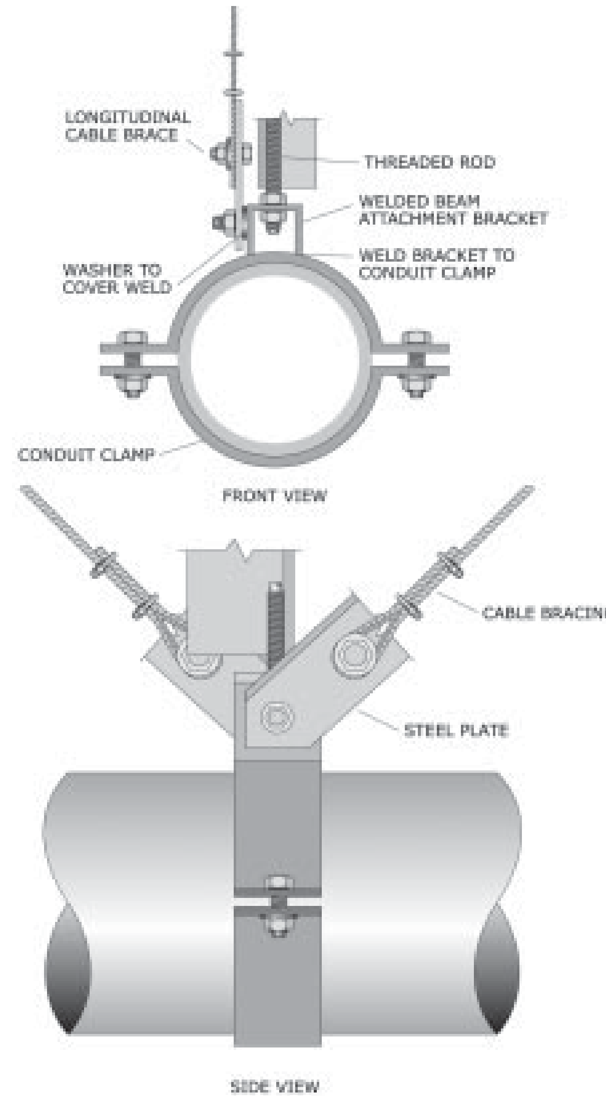


Figure 69: Conduit clamp supports with longitudinal cable lateral support and hanger rod.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring. For building structure attachment details see Figures 92 through 98 (pages 71 to 75). For instructions on installing anchors, see Anchors (page 104).

Building structures must be point load capable. Verify with the appropriate design professional.

Step 2: Run conduits as required by the approved construction documents

Step 3: Attach anchors to the building structure for lateral support restraints

For cable assembly instructions, see Cables (page 133). For details on attaching cable to the building structure, see Figure 100 (page 77). For angle and strut attachment, see Figure 103 (page 79). For instructions on installing anchors, see Anchors (page 104).

END OF ATTACHMENT.

Suspended with a trapeze support system

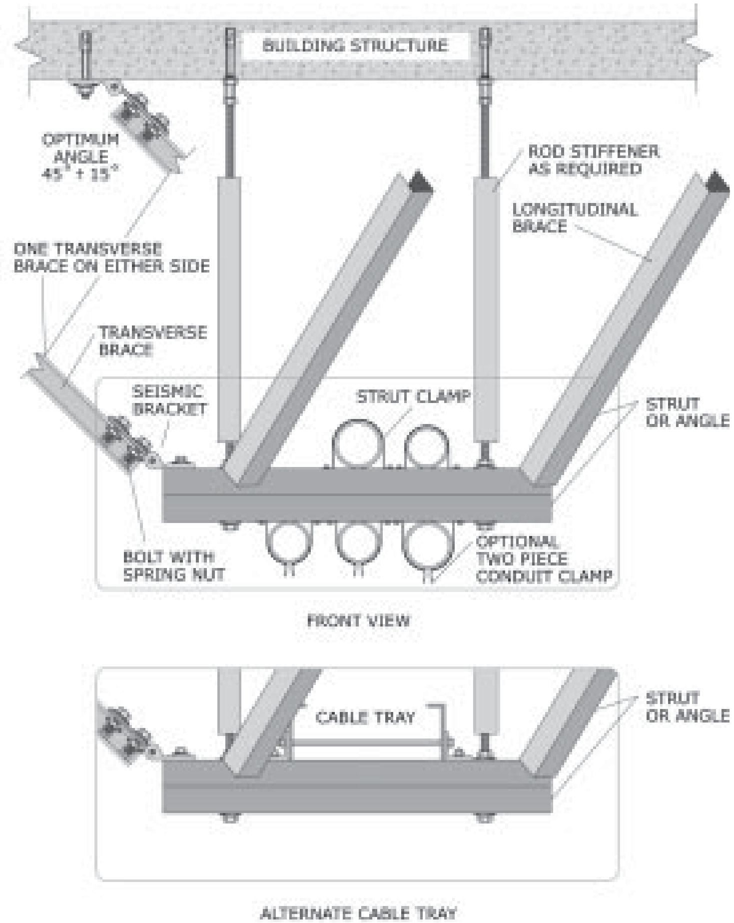


Figure 70: Trapeze support with strut or angle lateral supports.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 92 through 98 (pages 71 to 75). For instructions on installing anchors, see Anchors (page 104).

Building structures must be point load capable. Verify with the appropriate design professional.

Step 2: Run conduits as required by approved construction documents

Step 3: Attach anchors to the building structure for lateral support restraints

For cable assembly instructions, see Cables (page 133). For details on attaching cable to the building structure, see Figure 100 (page 77). For angle and strut attachment, see Figure 103 (page 79). For instructions on installing anchors, see Anchors (page 104).

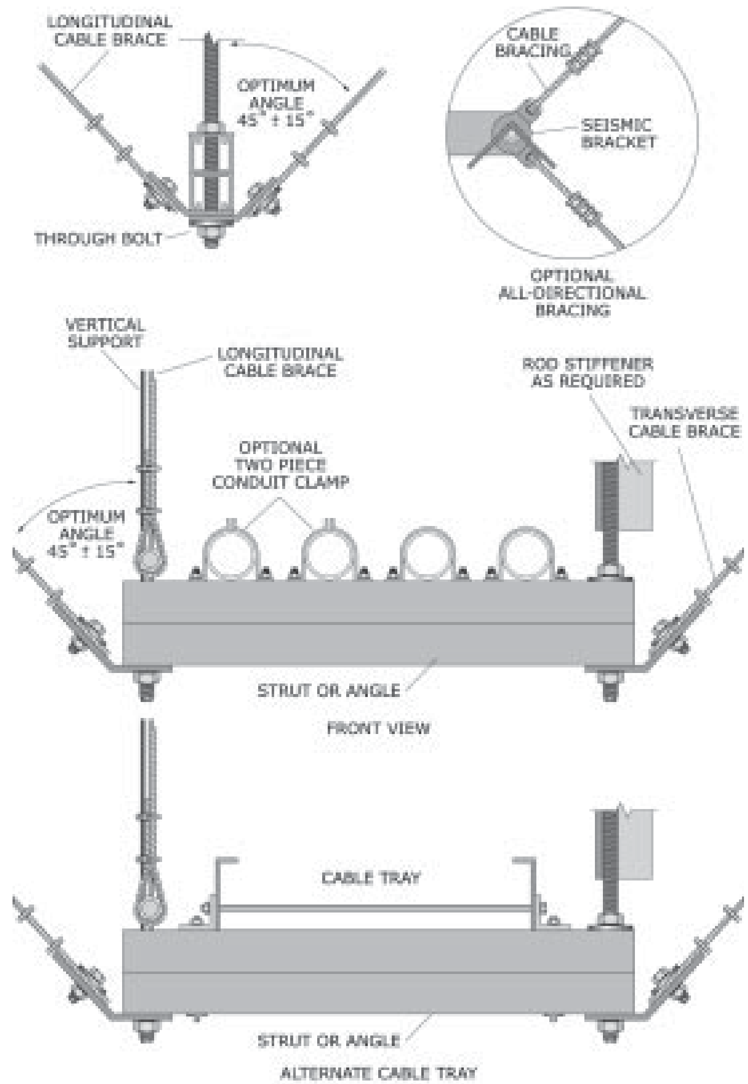


Figure 71: Trapeze support with cable lateral supports.

END OF ATTACHMENT.

Crossing seismic joints

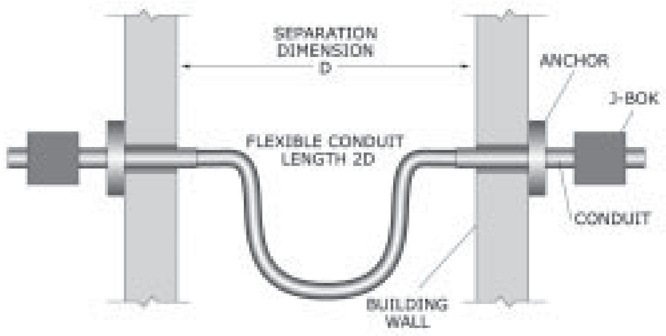


Figure 72: Seismic joint.

Step 1: Cross seismic joint with flexible conduit

Support conduits as required by approved construction documents. Add a flexible conduit support to allow differential movement in all directions.

END OF ATTACHMENT.

ATTACHMENT TYPES

This section gives instructions on attaching equipment to a building structure in various arrangements. The attachment types are:

- Rigid Floor-mounted/Pad-mounted (this page).
- Roof-mounted (page 65).
- Suspended (page 71).
- Vibration-isolated/Floor-mounted (page 87).
- Wall-mounted (page 98).

Rigid Floor-mounted/Pad-mounted Attachments

The four ways to rigidly attach equipment to a floor are:

- Directly to the floor/pad (this page).
- Using additional structural steel shapes that transfer load to the building floor/pad (page 55).
- Using bumpers to restrict horizontal movement (page 60).
- On a raised floor (page 61).

Directly to the floor/pad

Equipment may be bolted or welded to the building floor or pad. To bolt to concrete, use post-installed anchors, or embedded headed studs (see Anchors, page 104).

Attachment of equipment with sheet steel housings is shown in Figures 73 and 74 (page 52).

Attachment of equipment with a structural steel frame or base is shown in Figure 75 (page 53).

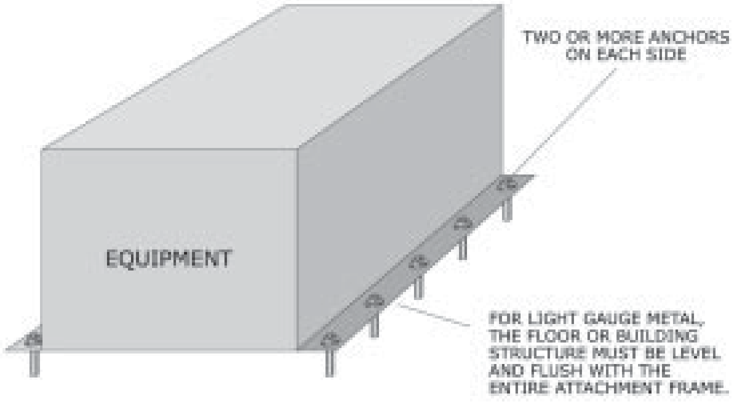


Figure 73: Direct attachment of equipment with sheet steel housing to a building.

Do not add shims under equipment with sheet steel housings as shown in Figure 73 above. If the concrete floor/pad is irregular, reinforce housing with angles as shown in Figure 77 (page 56).

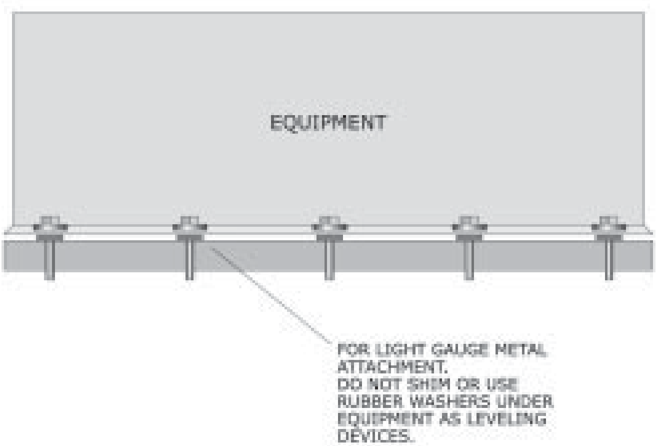


Figure 74: Side view of equipment with sheet steel housing.

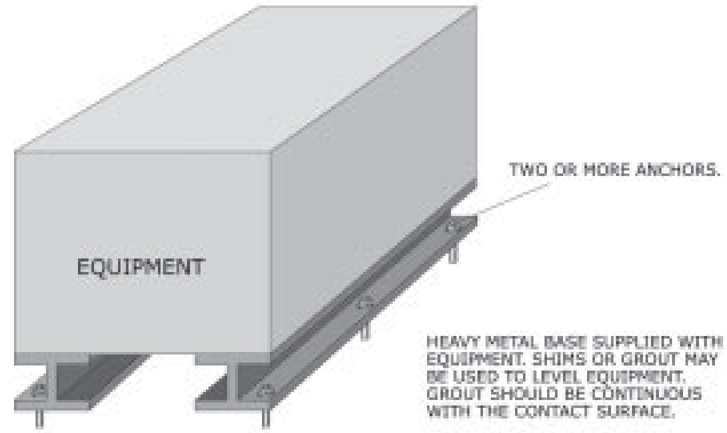


Figure 75: Direct attachment of equipment with structural steel frame or base to a building.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

It is preferred to use the holes provided by the manufacturer. Under supervisory approval, you may need to drill additional holes in the equipment assembly or building steel beams as shown on approved construction documents or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

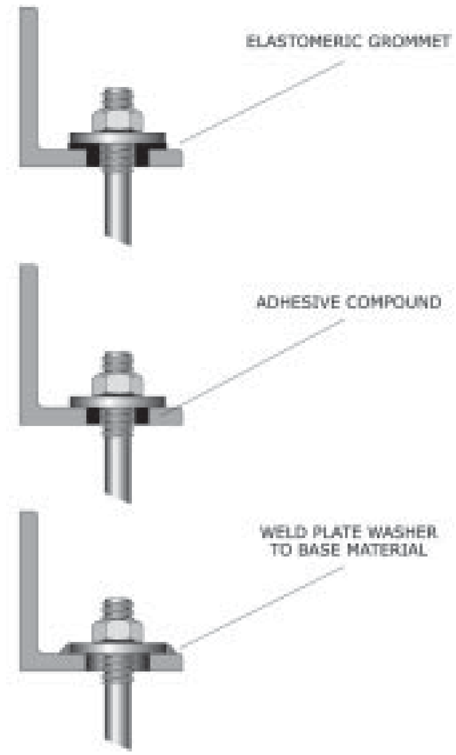


Figure 76: Three options to repair oversized holes.

Step 2: Install anchors

If the equipment is to be anchored to concrete, drill and install post-installed anchors or pour concrete with cast-in-place studs (see Anchors, page 104).

If the equipment is to be bolted to steel, drill holes in the steel as shown on approved construction documents or the manufacturer's instructions.

Step 3: Move equipment into place

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.

Step 4: Attach nuts or weld equipment

Attach nuts to the anchor/bolt and torque, see Anchors (page 104) or weld equipment to steel beams or embedded plates, see Welding (page 128).

Raceways, conduits, and cable trays may now be connected.

END OF ATTACHMENT.

Using additional structural steel shapes that transfer load to the building floor/pad

Attach additional structural shapes to the equipment with bolts and then attach steel shapes to the building with concrete anchors, steel bolts, or welding. When bolting to concrete, use post-installed anchors or embedded headed studs.

The five configurations for using angles to attach equipment to the building structure are:

- Full-size angles on each side of equipment (Figure 77, page 56).
- Four or more angles on each side of equipment bolted to the concrete floor/pad (Figure 78, page 57).
- Four or more angles welded to equipment and bolted to the floor/pad (Figure 79, page 57).
- Four or more angles on each side of equipment welded to embedded plates (Figure 80, page 58).
- Three or more angles used to bolt down equipment with a round base, (Figure 81, page 58).

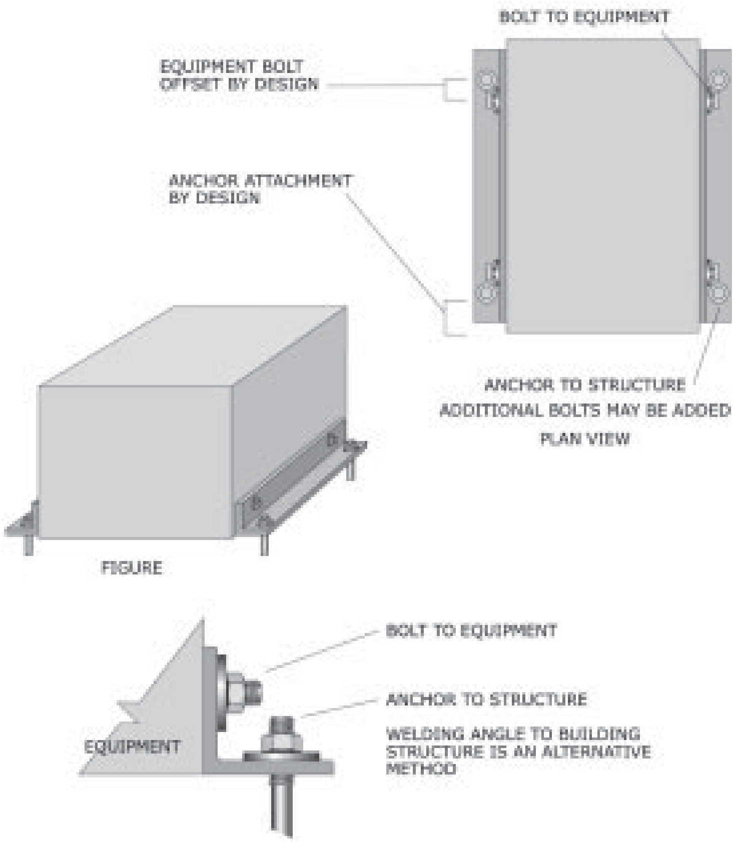


Figure 77: Two angles used to attach the equipment to the building.

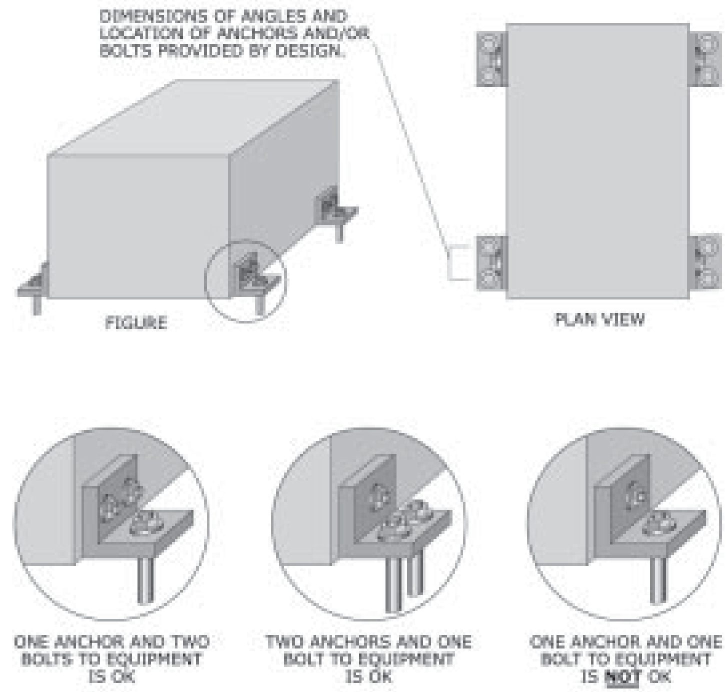


Figure 78: Four or more angles used to attach the equipment to the building.

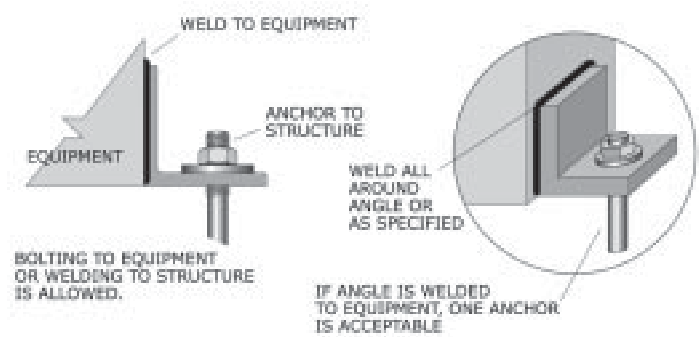


Figure 79: Four or more angles welded to equipment and bolted to the floor/pad.

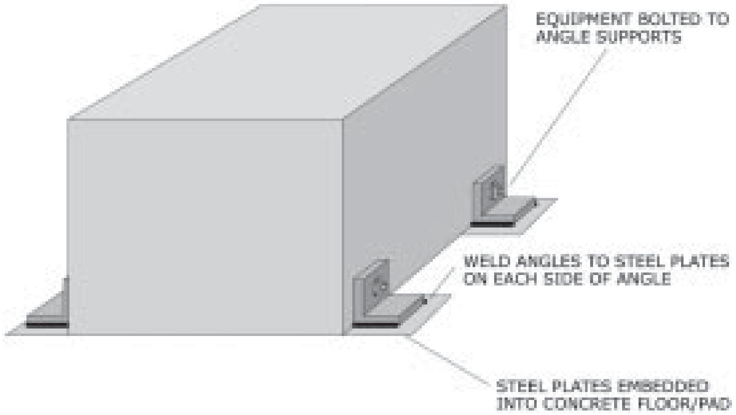


Figure 80: Four or more angles on each side of equipment welded to embedded plates. *Figure 148 (page 128) gives examples of embedded steel plates.*

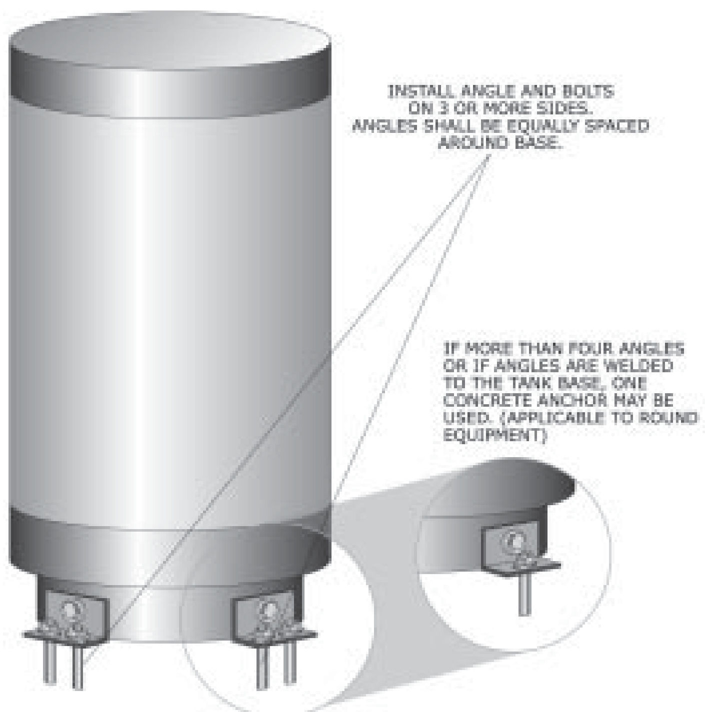


Figure 81: Three or more angles used to bolt down equipment with a round base.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

It is preferred to use the holes provided by the manufacturer. Under supervisory approval, you may need to drill additional holes in the equipment assembly or building steel beams as shown on approved construction documents or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

Step 2: Install anchors

If the equipment is to be anchored to concrete, drill and install post-installed anchors or pour concrete with embedded studs (see Anchors, page 104).

Step 3: Move the equipment into place

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.

You may bolt or weld angles to the equipment before moving the equipment into place.

Step 4: Attach nuts or weld equipment

Attach nuts to the anchor/bolt and torque (see Anchors, page 104 or Welding, page 128).

Raceways, conduits, and cable trays may now be connected.

END OF ATTACHMENT.

Using bumpers to restrict horizontal movement

Use this attachment type when equipment is mounted to a concrete inertia base or steel frame, but is not attached to the building. Refer to the Vibration-isolated/Floor-mounted Attachments section (page 87) for information on bumpers.

Bumpers are used to restrain the base from moving horizontally when there is no chance that the equipment will tip over. Bumpers are only bolted to the building structure. Use post-installed anchors to bolt to concrete, as shown in Figures 82 and 83 (below).

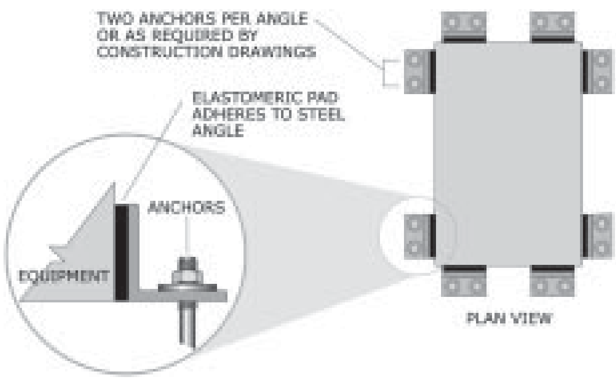


Figure 82: Equipment installed with bumpers.

If anchors are near a joint in the concrete, see detail in Figure 83.

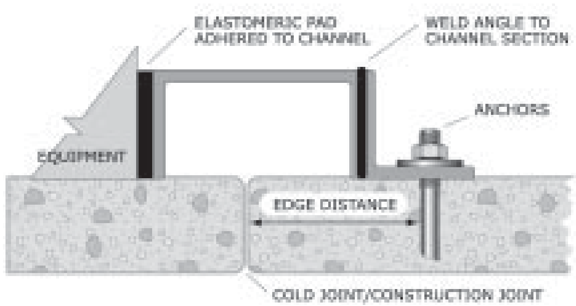


Figure 83: Alternate installation detail of bumpers installed near a concrete joint.

Attachments: Rigid Floor-mounted/Pad-mounted

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the bumpers in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

Step 2: Install anchors

For instructions on installing anchors, see Anchors (page 104). If the anchors are near a concrete joint, refer to the detail in Figure 83 (page 60).

Step 3: Install bumpers

Step 4: Attach nuts to the anchor/bolt and torque

For instructions on installing anchors, see Anchors (page 104). Figure 83 (page 60) shows equipment restrained with bumpers next to a cold joint.

END OF ATTACHMENT.

On a raised floor

Equipment set on a raised floor can be seismically attached to the building structure below. A stand rated for the weight of the equipment and laterally braced to withstand seismic loads must be provided. Equipment is rigidly attached to the stand and the stand is rigidly bolted to the floor beneath the raised floor. Portions of the raised floor are removed to allow installation of the stand and equipment as shown in Figures 84 (page 62), 85 (page 63) and 86 (page 64).

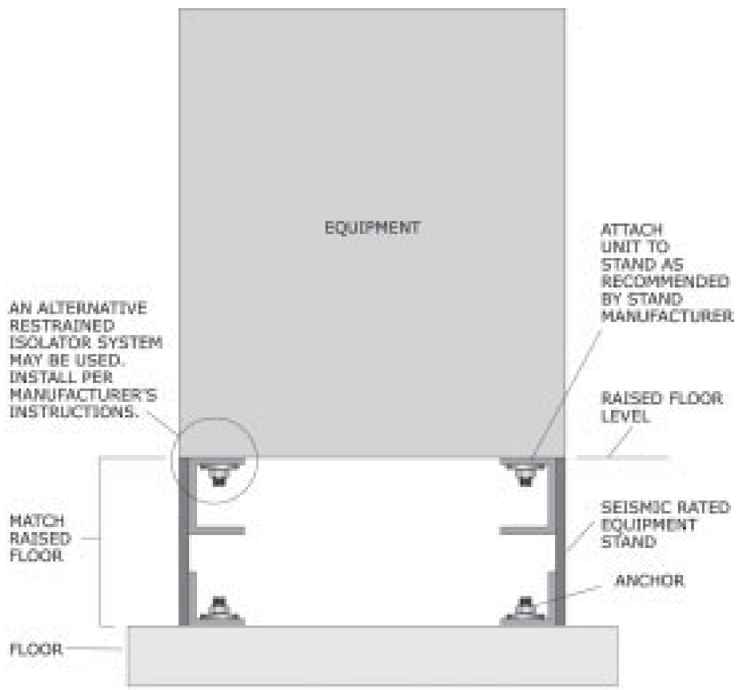


Figure 84: Electrical equipment installed on a raised floor.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor using one of the following methods:

- Set the frame in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

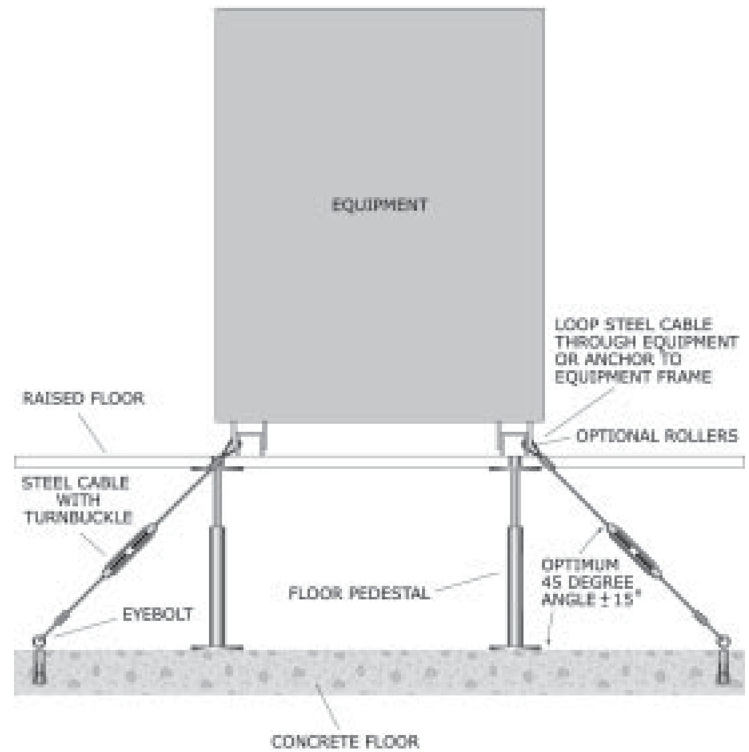


Figure 85: Equipment attached to cables beneath a raised floor.

Step 2: Install anchors

For instructions on installing anchors, see Anchors (page 104). Set the frame in place and apply nuts to the anchor/bolt and torque.

Verify with a supervisor that the weight of equipment will not exceed the capacity of the raised floor and that the floor can withstand a horizontal load.

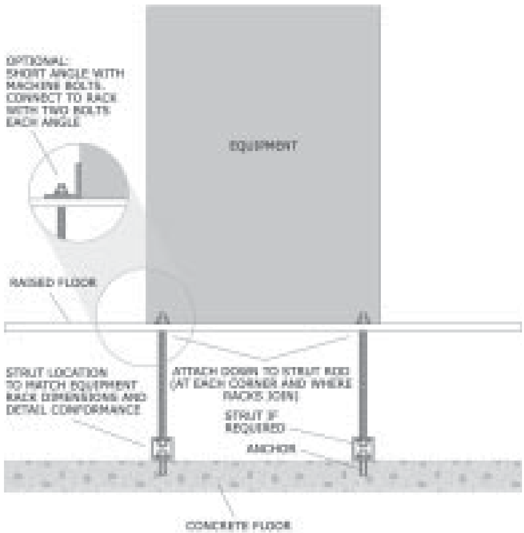


Figure 86: Equipment bolted beneath a raised floor.

Step 3: Move the equipment into place

Bolt the equipment to the frame (see Steel Bolt Connections, page 123) or bolt to strut as shown in Figure 86.

It is preferred to use the holes provided by the manufacturer. Under supervisory approval, you may need to drill additional holes in the equipment assembly or building steel beams as shown on approved construction documents or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

Raceways, conduits, and cable trays may now be connected.

END OF ATTACHMENT.

Roof-mounted Attachments

The three ways to attach equipment to a roof are:

- Using leveling stanchions—post and beam (this page).
- To a wood frame (page 68).
- Using restrained vibration isolators on leveling stanchions (page 69).

Using leveling stanchions—post and beam

Step 1: Attach posts or stanchions

Bolt or weld stanchions (also called post and beam) to the building structure. To attach stanchions to different building structure types, see the detail in Figure 87 (page 66).

Support stanchions can be made from many different structural shapes.

Coordinate attachment points with approved construction documents. Additional intermediate building structure beams may be required to accommodate the equipment.

The building structure must be capable of supporting the point load of the stanchions.

Step 2: Apply flashing to stanchions

Use standard details to flash around pipe stanchions or steel tubing. For flashing around a stanchion, which may not be uniform like an angle, channel, or I-beam steel shape, see Figure 88 (page 67).

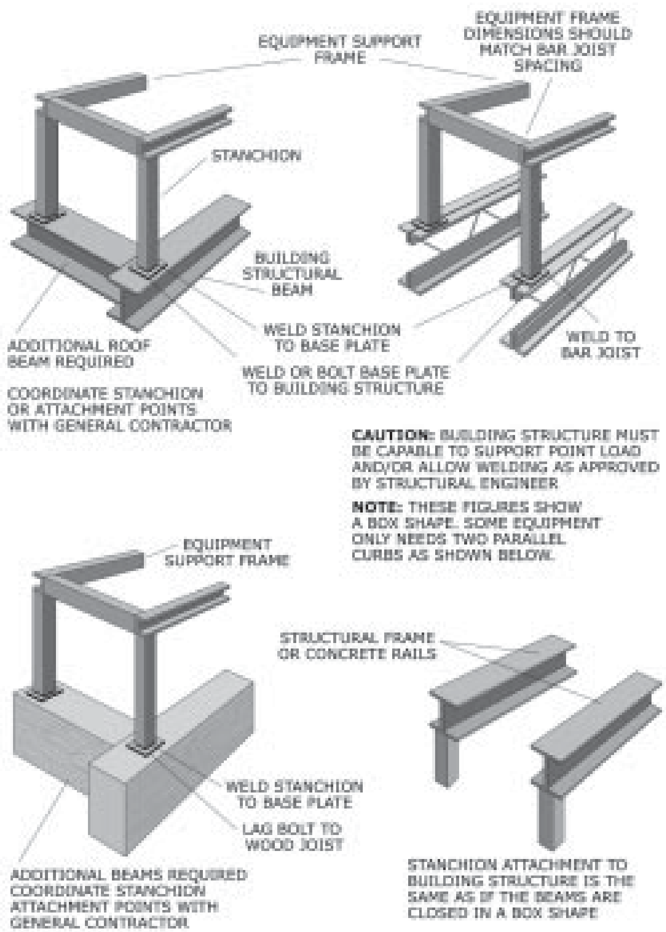


Figure 87: Attaching a stanchion to a building.

Step 3: Weld/bolt equipment support frame to stanchion

The equipment support frame may be box-shaped or have two parallel beams made from steel shapes such as angles, tubes, channels, or I-beams.

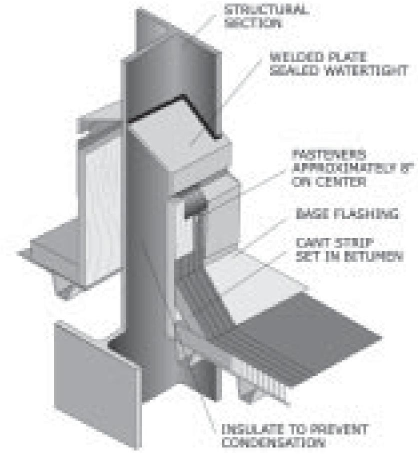


Figure 88: Flashing around a stanchion.

Step 4: Attach equipment

To rigidly attach the equipment to the equipment support frame, see Figure 89 (below).

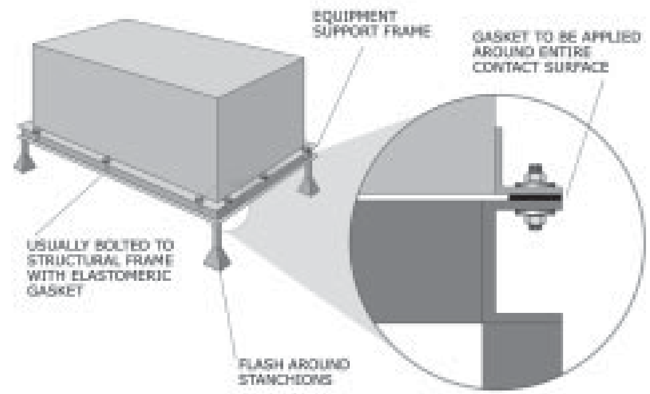


Figure 89: Rigid attachment of equipment to a support frame.

END OF ATTACHMENT.

To a wood frame

Step 1: Attach wood frame to building structure

Figure 90 (below) shows a typical wood frame (curb/rail) attachment.

Step 2: Install flashing

Figure 90 (below) shows typical flashing.

Use approved construction documents for flashing details.

Step 3: Attach equipment to the wood frame

Attach equipment directly to the wood frame as shown below. Wood frames can restrain equipment with internal frames or with support legs as shown.

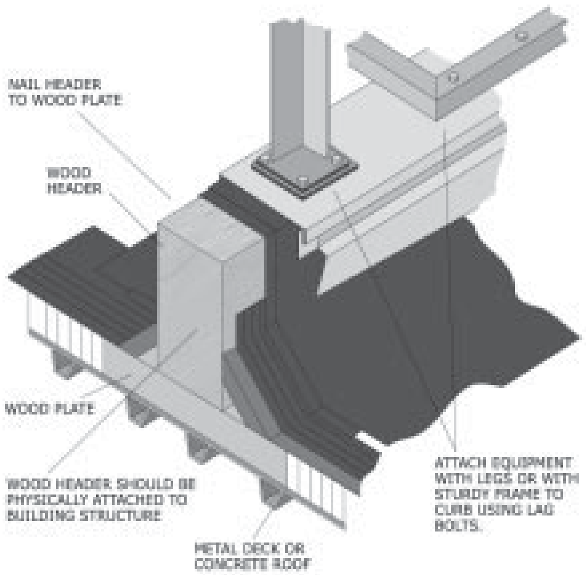


Figure 90: Attachment of equipment to a wood frame.

END OF ATTACHMENT.

Using restrained vibration isolators on leveling stanchions

Figure 91 (below) shows a typical installation of restrained vibration-isolated equipment on stanchions and an equipment support frame.

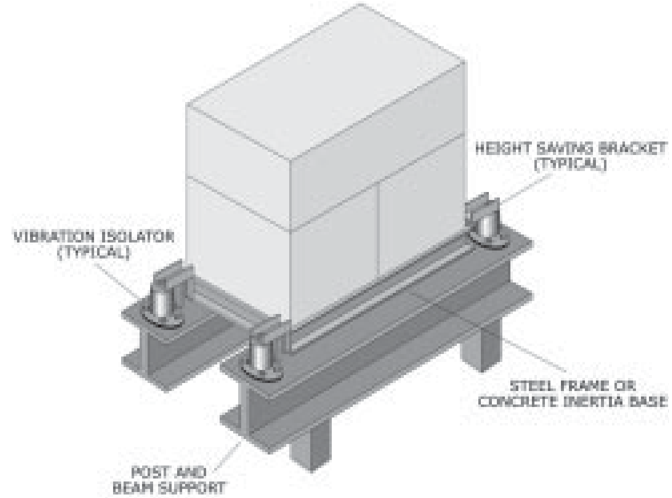


Figure 91: Equipment attached using restrained vibration islators on a post and beam support.

More than four restrained vibration isolators may be required. See the manufacturer's instructions.

Verify that each vibration isolator is properly aligned according to the manufacturer's recommended clearances. If the vibration isolator shaft rubs against the snubber element, vibration isolation may not function or noise problems may occur.

Step 1: Attach posts or stanchions

Bolt or weld stanchions to the building structure. Refer to the detail in Figure 87 (page 66) for attaching stanchions to different building structure types. Support stanchions can be made from many different structural shapes.

Coordinate attachment points with approved construction documents. Additional intermediate building structure beams may be required to accommodate the equipment.

The building structure must be capable of supporting the point load of the stanchions.

Step 2: Apply flashing to stanchions

Use standard details to flash around pipe stanchions or steel tubing. For flashing around a stanchion, which may not be uniform like an angle, channel, or I-beam steel shape, refer to Figure 88 (page 67).

Step 3: Weld/bolt equipment support frame to stanchions

The equipment support frame may be box-shaped or have two parallel beams. The equipment support frame may be made from steel shapes such as angles, tubes, channels, or I-beams.

Step 4: Attach restrained vibration isolators

Attach restrained vibration isolators to the support frame using steel bolts.

The support frame must be wider than the base plate of the restrained vibration isolator.

Step 5: Install equipment on vibration isolators

Install equipment on vibration isolators with attachment nuts and level.

Bases are required for mounting equipment with restrained vibration isolators.

END OF ATTACHMENT.

Suspended Attachments

Do not mix strut and cable bracing systems.

The five ways to suspend equipment are by:

- Rigid connection to the building structure using four threaded vertical rods with horizontal cable supports (this page).
- Rigid connection to the building structure using angle/strut supports (page 78).
- Vibration-isolated connection to the building structure using a minimum of four threaded vertical rods and lateral restraints (page 81).
- Two point equipment attachment - bolted to the building structure (page 84).
- Chain mounted or bar support with swivel (page 86).

Rigid connection to the building structure using four threaded vertical rods with horizontal cable supports

Equipment should have pre-installed brackets that can support the attachment to the building.

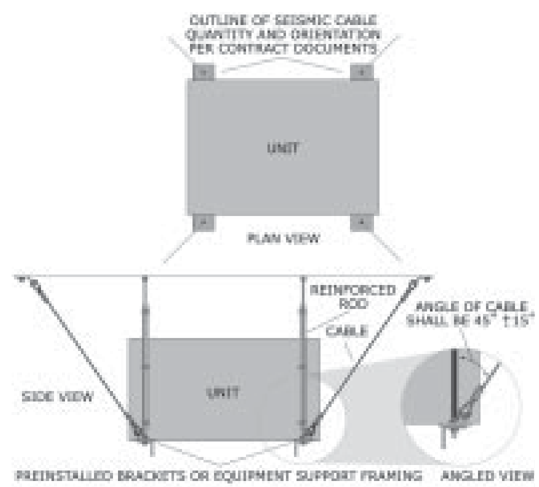


Figure 92: Rigid connection to the building structure.

Cables provide lateral bracing for seismic loads and should not be installed to hang equipment.

Step 1: Attach the equipment to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 92 to 98 (pages 71 to 75). For instructions on bolting directly to the building structure, see Steel Bolt Connections (page 123).

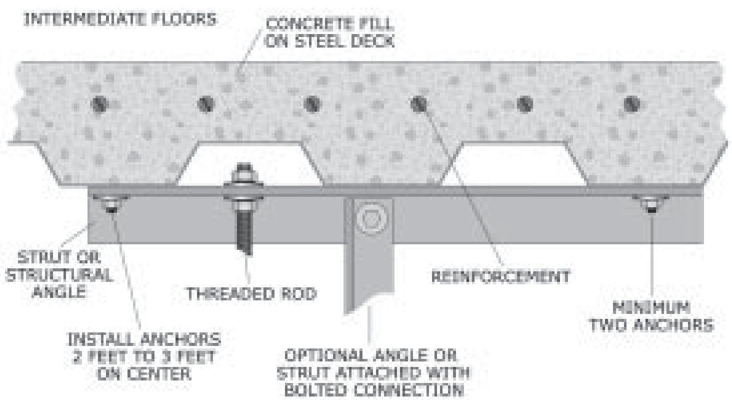


Figure 93: Cast-in-place anchor; concrete fill on steel deck.

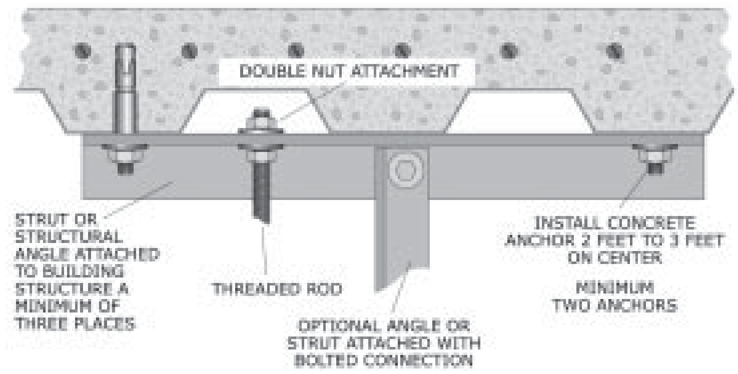


Figure 94: Post-installed anchor; concrete fill on steel deck.

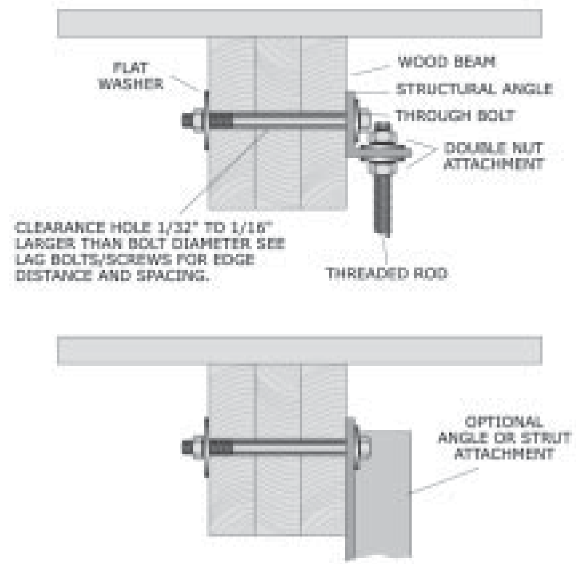


Figure 95: Wood beam construction.

For edge distances and spacing, see Lag Bolts (page 112).

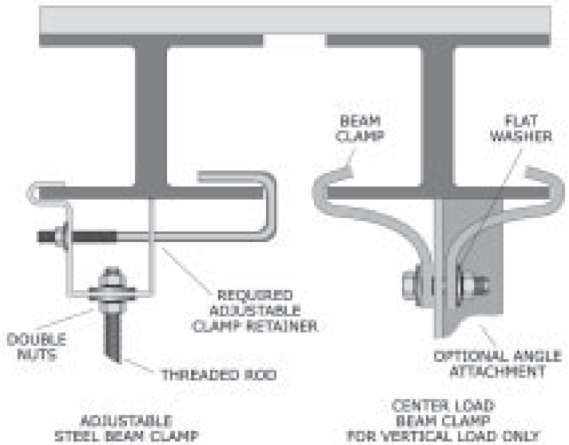


Figure 96: Steel beam construction.

Use center load beam clamps for vertical loads. Do not use for cables, rods, or structural members positioned at an angle.

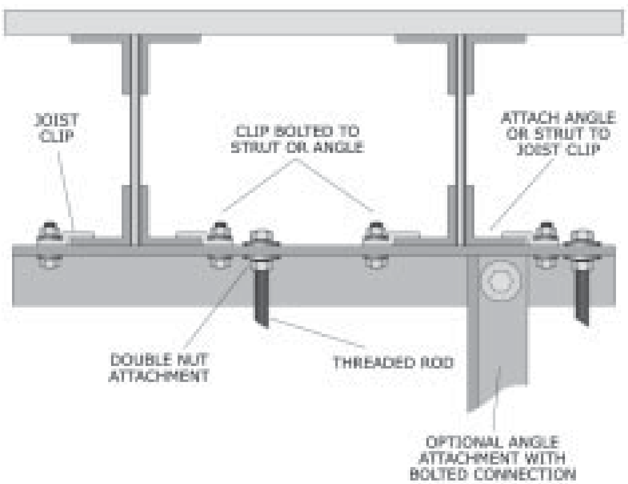


Figure 97: Bar joist construction.

Use center load beam clamps for vertical loads. Do not use for cables, rods, or structural members positioned at an angle.

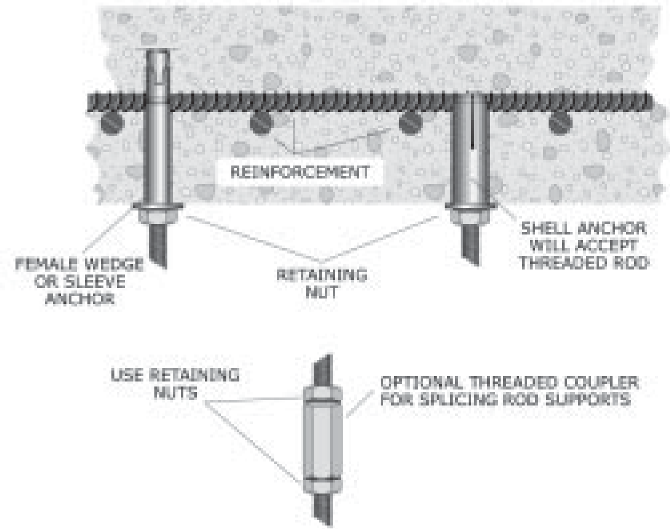


Figure 98: Concrete slab construction.

Step 2: Add rod stiffeners, as required

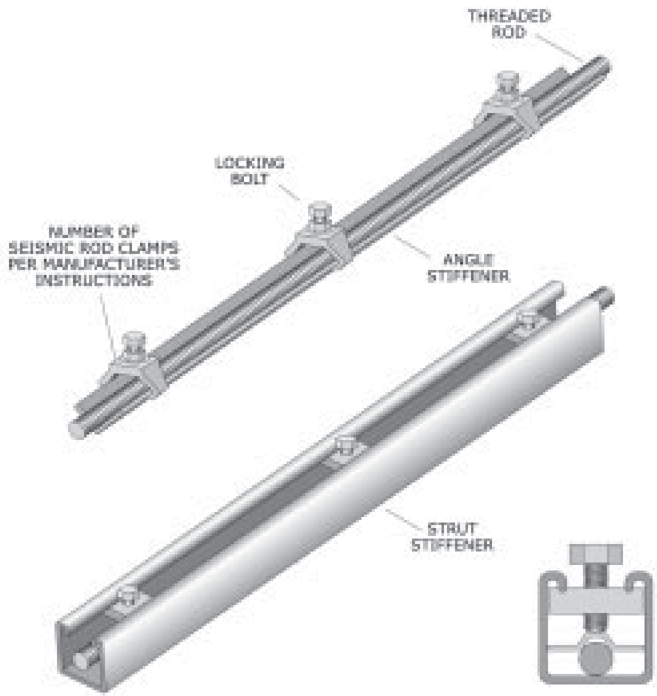


Figure 99: Rod stiffeners.

Step 3: Attach anchors to the building structure for cable attachment

Figure 100 (page 77) shows typical anchorage to different building construction. For instructions on installing anchors, see Anchors (page 104).

Step 4: Attach cable to the building structure

For cable assembly instructions, see Cables (page 133). For details on attaching cable to the building structure, see Figure 100 (page 77).

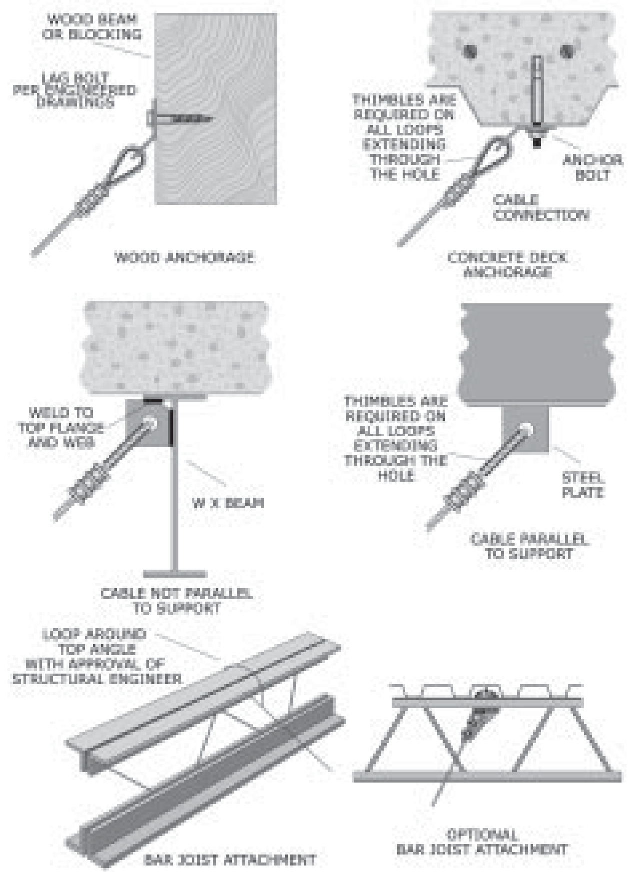


Figure 100: Attachments to the building structure.

For edge distances and spacing, see Lag Bolts (page 112).

Do not attach bracing to bottom of bar joist.

Step 5: Attach cables to equipment

For details on attaching cable to the equipment, see Figure 101 (page 78).

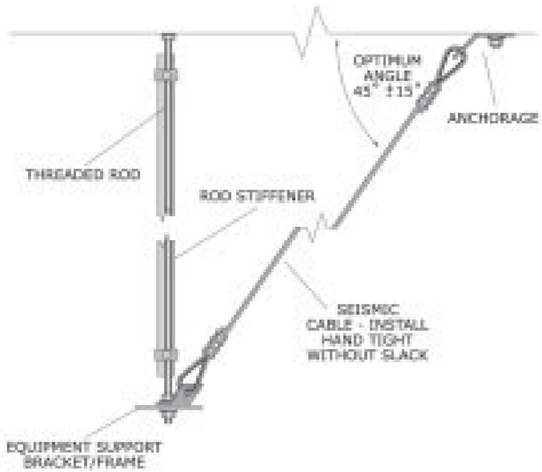


Figure 101: Attachment of cable to the equipment.

END OF ATTACHMENT.

Rigid connection to the building structure using angle/ strut supports

Equipment may have pre-installed brackets for angle support attachments as shown below in Figure 102.

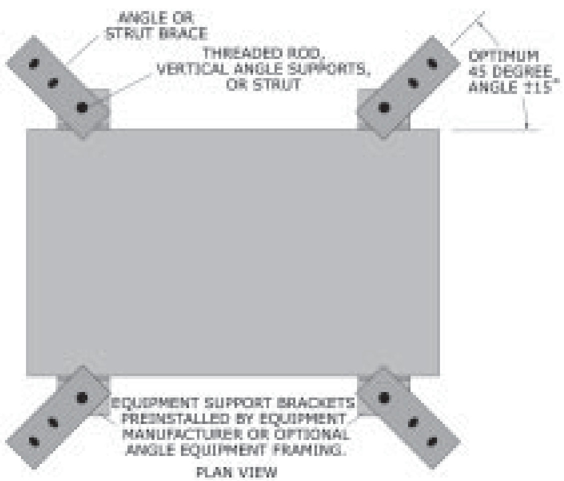


Figure 102: Rigid attachment of angles to the building structure.

Step 1: Attach the equipment to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring. For building structure attachment details, see Figures 92 to 98 (pages 71 to 75). For instructions on installing anchors, see Anchors (page 104). Rod stiffeners may be required.

Step 2: Attach anchors to the building structure for angle or strut supports

For building structure attachment details, see Figures 92 to 98 (pages 71 to 75). For instructions on installing anchors, see Anchors (page 104).

Step 3: Attach angles or strut supports to the building structure

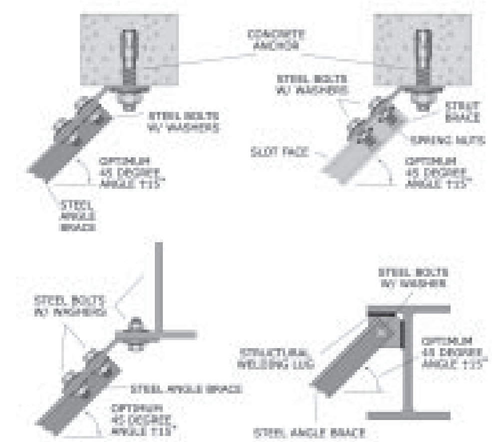


Figure 103: Attachment of angle or strut to the building structure.

Refer to approved construction documents for other attachments that may be permitted, similar to Figure 100 on page 77 (wood and bar joist).

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Attachment to bottom of beam if permitted by approved construction documents.

Step 4: Attach angle or strut to equipment

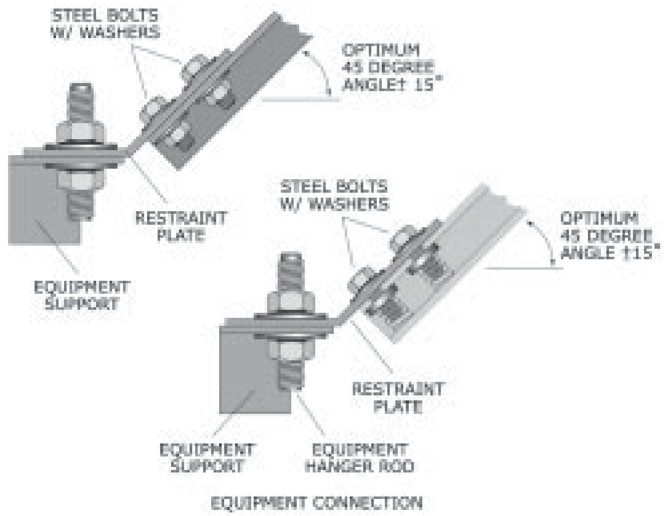


Figure 104: Attachment of angle or strut to the equipment.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

END OF ATTACHMENT.

Vibration-isolated connection to the building structure using a minimum of four threaded vertical rods and lateral restraints

Equipment may have pre-installed brackets for angle support attachments. See Figures 105 and 106 (below).

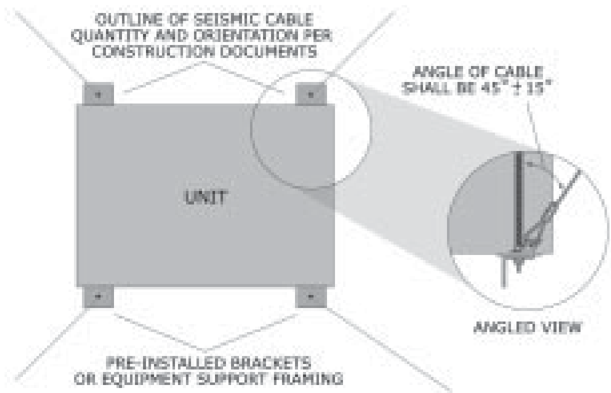


Figure 105: Plan view of vibration isolation suspended attachment to the building structure.

The side view (below) shows vibration isolators, rods (without rod stiffeners), and cables.

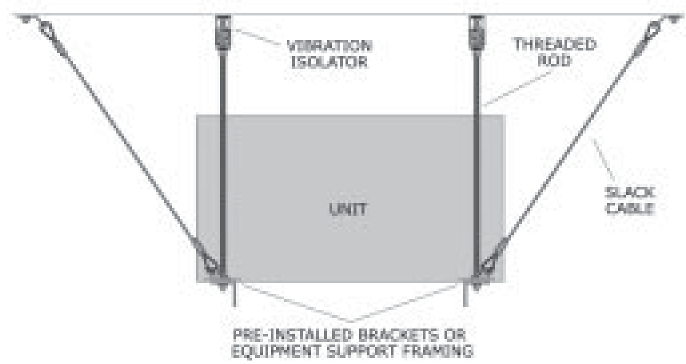


Figure 106: Side view of vibration isolation suspended attachment to the building structure.

Step 1: Attach equipment to the building structure using threaded rods, isolators and anchors

For the isolator detail, see Figure 107 (below). For building structure attachment details, see Figures 92 to 98 (pages 71 to 75).

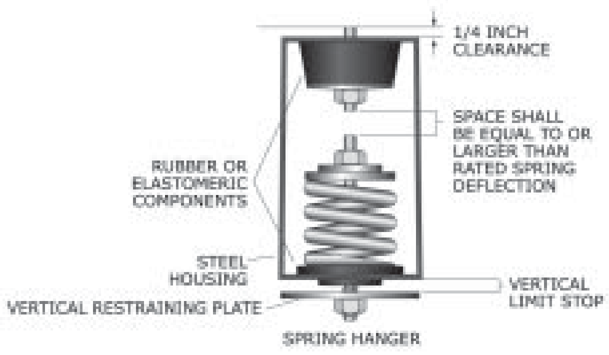


Figure 107: Isolator detail.

Step 2: Attach anchors and cable to the building structure

For details on attaching cable to the building structure, see Figure 100 (page 77). For instructions on installing anchors, see Anchors (page 104).

Step 3: Attach cables to equipment

For cable assembly instructions, see Cables (page 133). For details on attaching the vibration-isolated cable/rod assembly to the equipment, see Figure 108 (page 83).

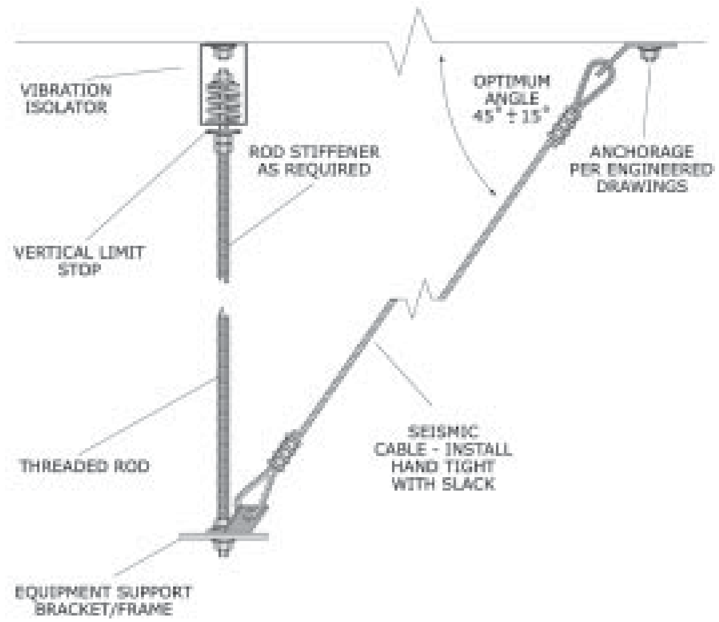


Figure 108: Attachment of cable/rod assembly to the equipment.

END OF ATTACHMENT.

Two point equipment attachment — bolted to the building structure

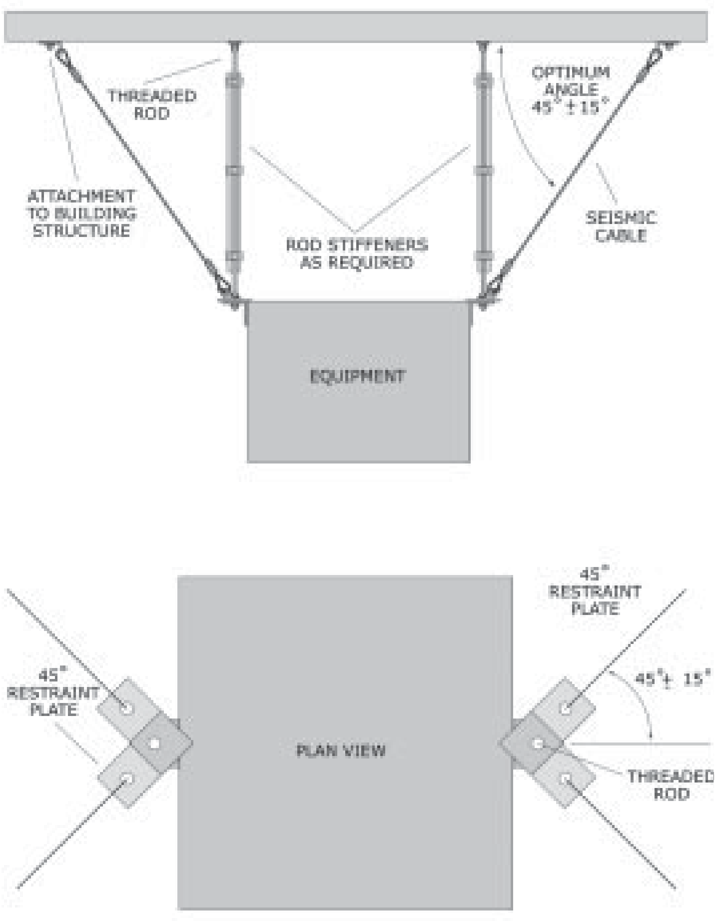


Figure 109: Two point equipment attachment.

Use this type of installation for unit heaters.

Step 1: Attach anchors and vertical rods to the building structure

Lay out all attachment points before anchoring. For building structure attchment details, see Figures 92 to 98 (page 71 to 75). Attach equipment to the vertical rods.

The attachment should be located just above the center of gravity to minimize swinging. It should be a rigid attachment with brackets to the equipment using double nuts and washers, especially if connected at the top as shown in Figure 109 (page 84).

Step 2: Attach rod stiffners

For attachment details, refer to Figure 99 (page 76).

Step 3: Attach anchors to the building for cable attachment

Figure 100 (page 77) shows typical anchorage to different building construction. For instructions on installing anchors, see Anchors (page 104).

Step 4: Attach cable to the building structure

For cable assembly instructions, see Cables (page 133). For details on attaching cable to the building structure, see Figure 100 (page 77).

Step 5: Attach cables to equipment

The detail in Figure 109 (page 84) shows the attachment to the equipment.

END OF ATTACHMENT.

Chain mounted or bar support with swivel

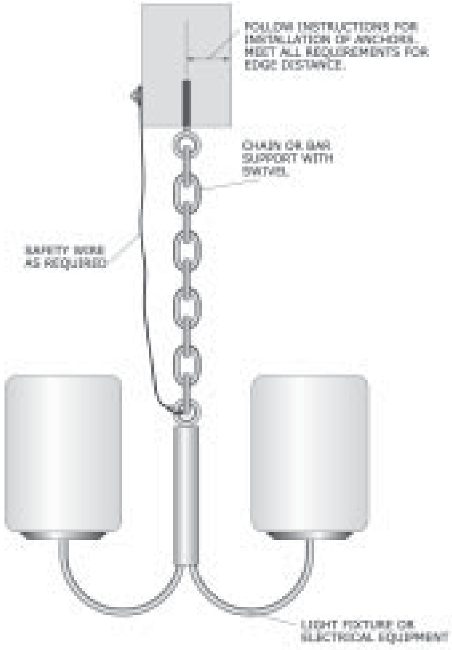


Figure 110: Chain mounted or bar support with swivel.

Step 1: Attach anchor to the building structure

Lay out all attachment points before anchoring. Follow all requirements for anchors. For instructions on installing anchors, see Anchors (page 104).

Step 2: Attach chain or bar to anchor

Attachment should allow the chain or bar to swing freely in all directions without binding.

Swinging motion should not be obstructed by other objects within the vicinity of the equipment supported by the chain.

Design of anchorage must consider the sway of the light fixture during a seismic event.

END OF ATTACHMENT.

Vibration-isolated/Floor-mounted Attachments

Vibration isolation uses several different springs or isolation pads to isolate equipment vibrations from the building structure. Vibration isolators can be open (see Figure 111, left), housed (see Figure 111, right), and restrained (see Figure 112, page 88).

NEVER USE HOUSED VIBRATION ISOLATORS FOR SEISMIC RESTRAINT APPLICATIONS. Housed isolators cannot resist uplift.

Snubbers (see Figure 113, page 88) are restraint devices to limit the movement of equipment that is isolated. Bumpers (see Figure 114, page 89) also limit the movement of equipment and are similar to snubbers.

NEVER USE SNUBBERS THAT ARE NOT SPECIFIED. Some snubbers only restrict movement in one direction.

NEVER USE OPEN VIBRATION ISOLATORS WITHOUT SNUBBERS OR BUMPERS.

Bases are steel structures made from angles, channels, or I-beams.

Bases are required for mounting isolated equipment and rated for point loads. The equipment or isolator manufacturer may provide the bases.

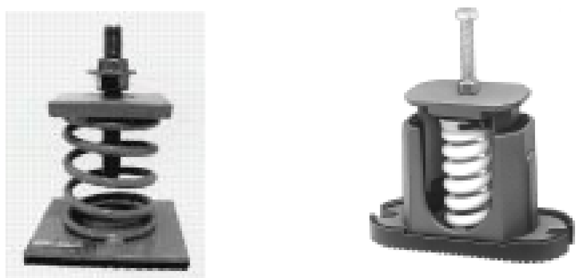


Figure 111: Open (left) and housed (right) vibration isolators.

Figure 112: Four types of restrained vibration isolators.

Verify that the vibration isolator is properly aligned according to the manufacturer's clearances. If the vibration isolator shaft rubs against the snubber element, vibration isolation may not function or noise problems may occur.

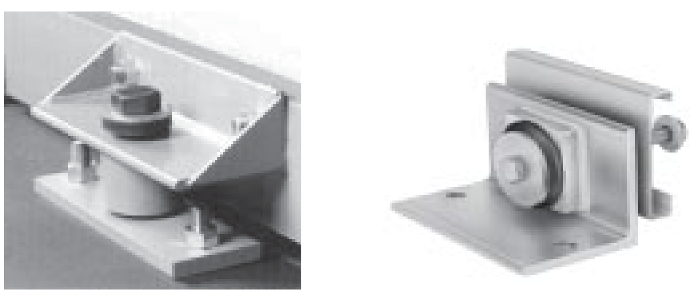


Figure 113: Two examples of snubbers.

Attachments: Vibration-isolated/Floor-mounted

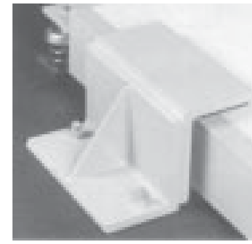


Figure 114: Example of a bumper.

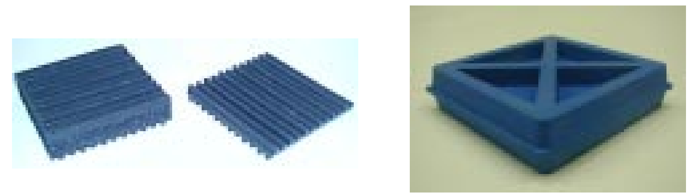


Figure 115: Vibration isolation pads.

Isolation pads may be placed under electrical equipment to reduce noise transmission to the building structure. Vibration isolation pads may be made of molded rubber, coated fiberglass, cork and various combinations thereof (see Figure 115 above for examples).

Figure 116: Rubber mounts.

Rubber mounts may be used to isolate equipment. See Figure 116 right, for rubber mounts with threaded steel inserts; left, for restrained rubber mounts.

The three ways of attaching vibration-isolated/floor-mounted equipment are on:

- Restrained vibration isolators (this page).
- Open isolators combined with snubbers (page 93).
- Elastomeric pads with isolated anchors (page 96).

Restrained vibration isolators

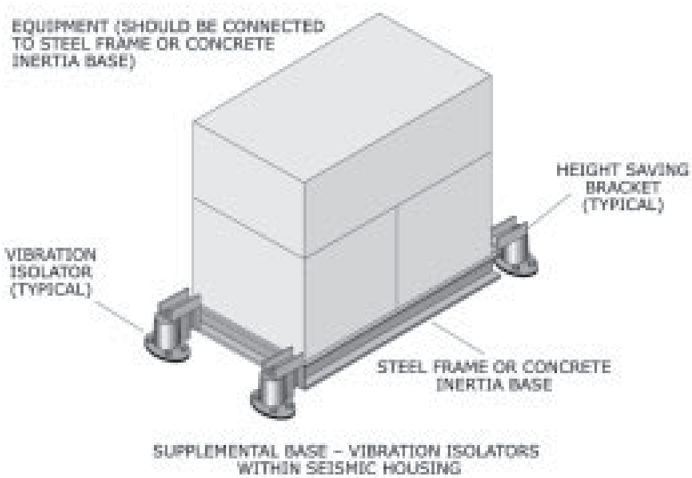


Figure 117: Typical installation of restrained vibration isolators.

More than four restrained vibration isolators may be required. See the manufacturer's instructions.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor or pad using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

Attachments: Vibration-isolated/Floor-mounted

Step 2: Install anchors

Drill and install post-installed anchors or pour concrete with embedded studs. For instructions on installing anchors, see Anchors (page 104).

Step 3: Set restrained isolators and bolt to anchors

Install restrained isolators to the building structure as shown in Figure 118 (below). Attach nuts to the anchor. Use bolts for shell-type anchors or internally threaded wedge or chemical anchors.

Torque bolts per manufacturer's recommendations.

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT OR ISOLATORS.

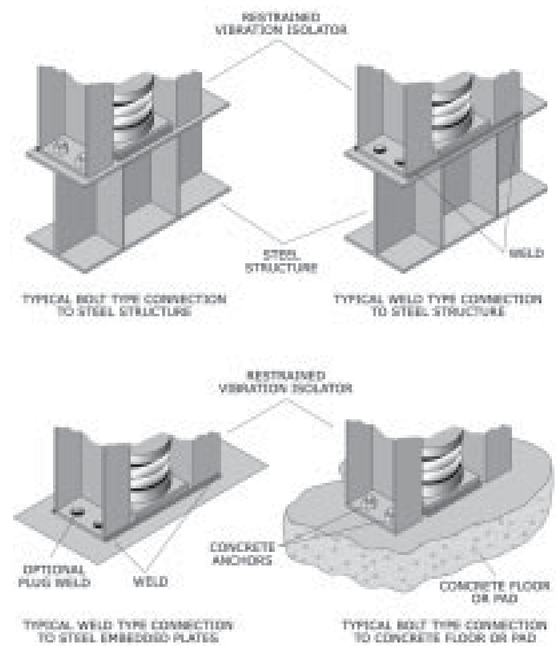


Figure 118: Attachment of restrained vibration isolators to the building structure.

Step 4: Move the equipment into place over the isolators

Use leveling nuts to level the equipment. Use attachment nuts to attach the base of the equipment to the isolator.

Figure 119 (below) shows typical ways to connect the equipment to the restrained isolators.

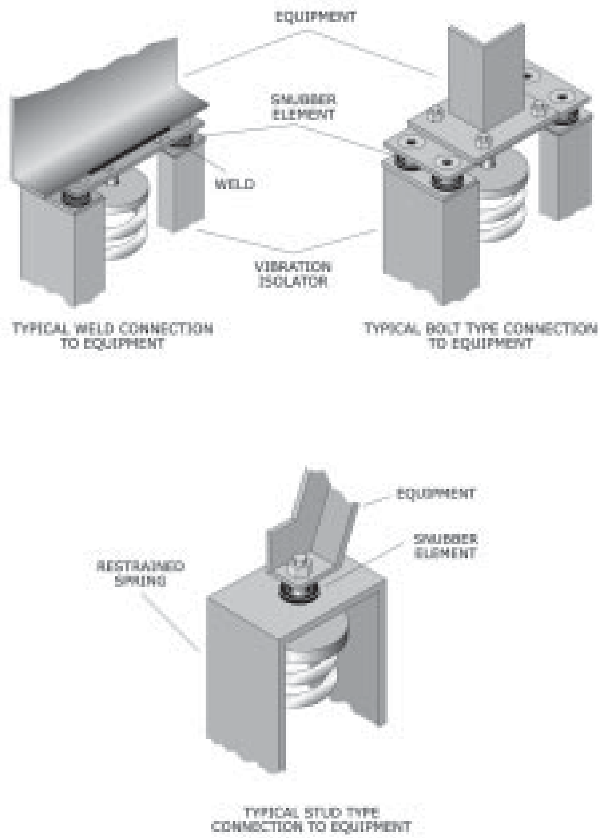


Figure 119: Attachment of equipment to restrained vibration isolators.

END OF ATTACHMENT.

Open isolators combined with snubbers

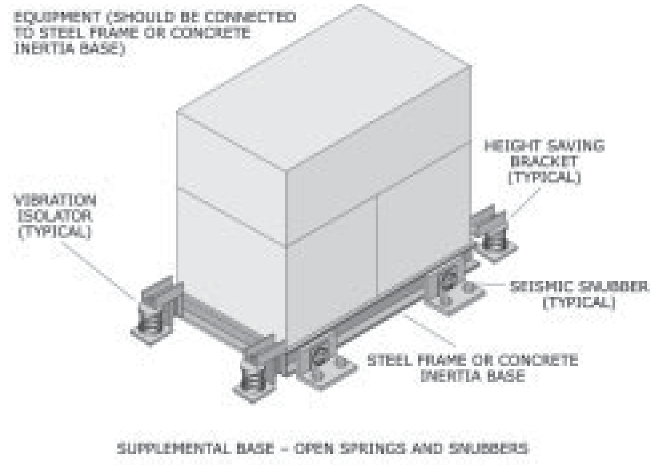


Figure 120: Typical installation of open isolators and snubbers.

Additional snubbers may be required. See the manufacturer's instructions.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern for the open isolator mounting plate on the floor or pad using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

Step 2: Install post-installed anchors for open isolators only *(snubbers are covered in later steps)*

Drill and install post-installed anchors for open isolators. For instructions on installing anchors, see Anchors (page 104).

Step 3: Attach open isolators to concrete floor or pad with anchors installed in Step 2

Set isolators, apply nuts and torque. Use bolts for shell-type anchors or internally threaded wedge or chemical anchors.

Torque bolts per manufacturer's recommendations.

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT OR ISOLATORS.

Step 4: Set equipment on open isolators

Set equipment on isolators but do not level or torque attachment nuts.

Equipment structural frame must be point load capable at the open spring isolators.

Some installations require the base to be concrete-filled. See Figure 121 (below) for a typical concrete-filled installation.

Coordinate the attachment point locations of the equipment and snubbers *before* filling with concrete.

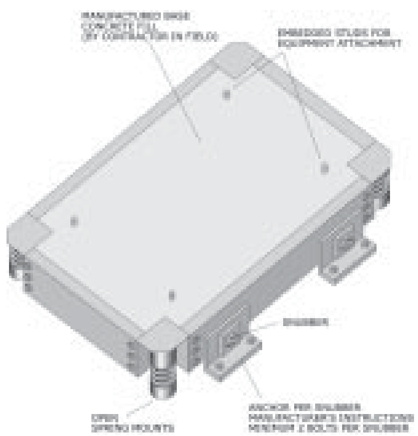


Figure 121: Concrete-filled inertia base.

Step 5: Determine where to attach snubber equipment assembly

A snubber has two assemblies: the snubber equipment assembly and the snubber base assembly.

Level the equipment. Final leveling will be required in later steps. Accurately draw the bolt pattern for the snubber equipment assembly mounting plate on the floor or pad and on the equipment.

All clearance requirements for aligning the snubber must be met. Shims may be provided.

Step 6: Attach snubber equipment assembly to equipment

Attach the snubber equipment assembly to the equipment by bolting it to embedded bolts in a concrete-filled base (see Figure 121, page 94), or by bolting or welding it to a steel base.

Step 7: Determine where to bolt snubber base

Accurately draw the bolt pattern for the snubber mounting plate on the floor or pad.

Step 8: Drill and install post-installed anchors

For instructions on installing anchors, see Anchors (page 104).

Step 9: Raise the equipment

Raise the equipment to allow the snubber base assembly to be placed over the anchors installed in Step 6.

Step 10: Lower the equipment

Level equipment and connect the two snubber assemblies as specified in the manufacturer's instructions. Verify that spacing requirements are met. Complete the final attachment to open isolators.

DO NOT INSTALL THE ISOLATORS OR SNUBBERS IN ANY CONFIGURATION OTHER THAN THAT SHOWN IN THE MANUFACTURER'S INSTRUCTIONS.

The equipment is now installed to resist earthquakes. Flexible piping, ductwork, and conduit connections must be used when connecting systems to isolated equipment.

END OF ATTACHMENT.

Elastomeric pads with isolated anchors

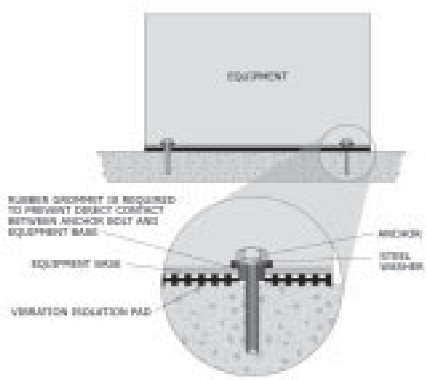


Figure 122: Elastomeric pads with isolated anchors.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the floor, concrete pad, or steel beams using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

Attachments: Vibration-isolated/Floor-mounted

It is preferred to use the holes provided by the manufacturer. Under supervisory approval, you may need to drill additional holes in the equipment assembly or building steel beams as shown on approved construction documents or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

Step 2: Install anchors

If the equipment is to be anchored to concrete, drill and install post-installed anchors or pour concrete with cast-in-place studs (see Anchors, page 104).

If the equipment is to be bolted to steel, drill holes in the steel as shown on approved construction documents or the manufacturer's instructions.

Step 3: Move equipment into place

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.

Step 4: Attach nuts or weld equipment

Attach nuts to the anchor/bolt and torque, see Anchors (page 104) or weld equipment to steel beams or embedded plates, see Welding (page 128).

Raceways, conduits, and cable trays may now be connected.

END OF ATTACHMENT.

Wall-mounted Attachments

Use the instructions for mounting "Directly to the wall" (below) for equipment surface-mounted on the underside of a building structural slab or rated structural ceiling.

The three types of wall mounting are:

- Directly to the wall (this page).
- To additional structural steel shapes attached to the wall (page 100).
- Vibration-isolated off the wall (page 102).

Directly to the wall

Equipment should have pre-installed brackets that can support attachment to the building as shown in Figure 123 (below).

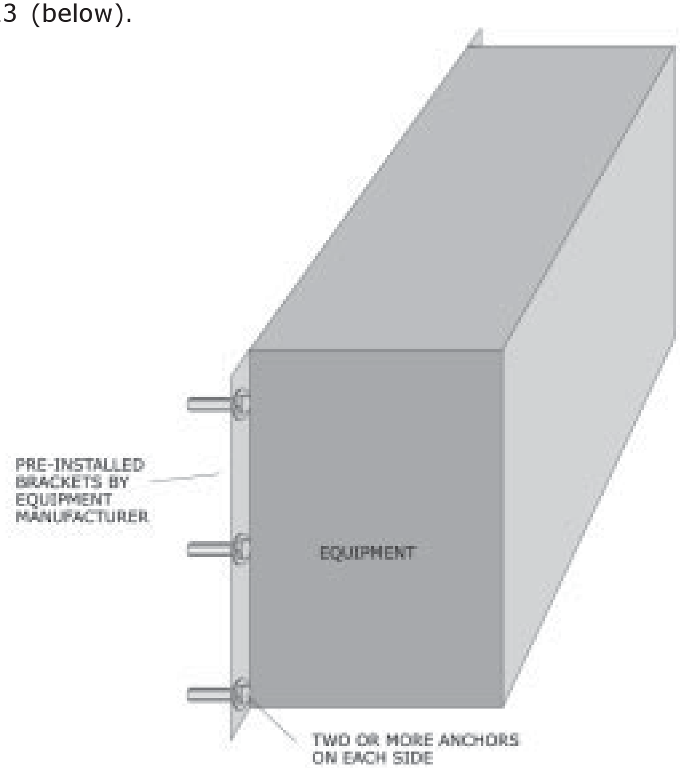


Figure 123: Direct attachment to a wall.

Step 1: Determine where to bolt the equipment

Accurately draw the bolt pattern on the wall using one of the following methods:

- Set the equipment in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

Drywall or masonry walls may require additional holes in equipment attachment brackets as shown on approved construction documents or in the equipment manufacturer's instructions.

ONLY USE MOUNTING BRACKETS PROVIDED. DO NOT DRILL INTO THE EQUIPMENT HOUSING.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

Step 2: Install post-installed anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 104, or Masonry and Drywall Anchors, page 114).

Step 3: Move the equipment into place

BE CAREFUL NOT TO DAMAGE THE ANCHORS WHEN SETTING THE EQUIPMENT.

Step 4: Attach nuts

Attach nuts to the anchor or bolt and torque according to the manufacturer's instructions.

Raceways, conduits, and cable trays may now be connected.

END OF ATTACHMENT.

To additional structural steel shapes attached to the wall

Equipment attaches to the wall with additional structural steel shapes and bolts. Shapes may be welded. These steel shapes are attached to the building using concrete, masonry, or drywall anchors.

Figure 124 (below) shows how angles and struts can be used for attachment to a wall. Angles and struts must accommodate wall construction attachment points and obstructions. Figure 157 (page 142) shows the direct attachment of a strut assembly.

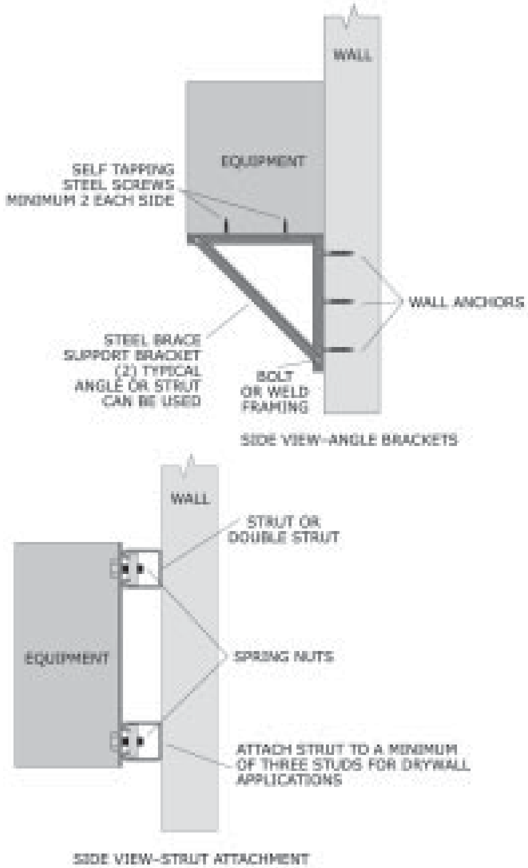


Figure 124: Angle or strut support.

Electric water heaters may be attached to the wall with a simple strap arrangement, as shown in Figure 125 (below).

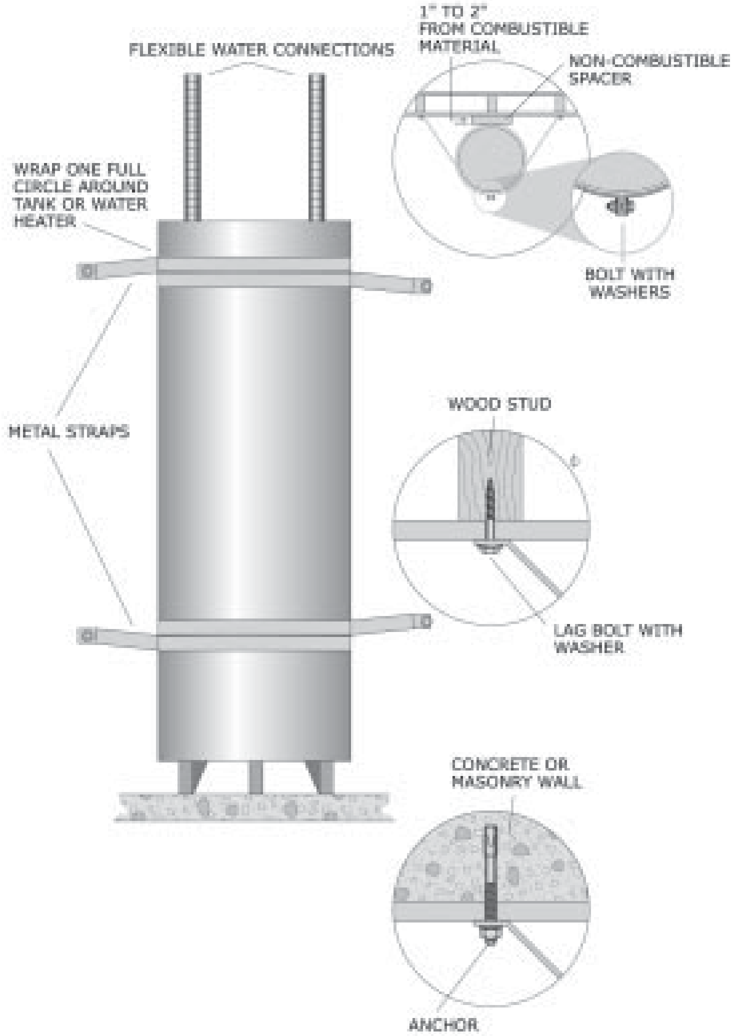


Figure 125: Electric water heater attachment.

Step 1: Determine the anchor locations

Find studs in drywall. Use measurements and construction drawings to lay out the bolt hole pattern and mark the anchor locations.

Step 2: Install anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 104, or Masonry and Drywall Anchors, page 114).

Step 3: Move equipment into place and bolt to frame

It is preferred to use the holes provided by the manufacturer. Under supervisory approval, you may need to drill additional holes in the equipment assembly or building steel beams as shown on approved construction documents or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

Raceways, conduits, and cable trays may now be connected.

END OF ATTACHMENT.

Vibration-isolated off the wall

Equipment attaches to the wall with additional structural steel shapes, threaded rods and vibration isolators. Shapes may be welded. These steel shapes are attached to the building using concrete, masonry, or drywall anchors.

Figure 126 (page 103) shows how rods, angles and struts can be used to isolate equipment attached to a wall. Angles and struts accommodate wall construction attachment points.

Vibration-isolation of equipment reduces the transmission of equipment noise and vibration into the building structure. See Figure 107 (page 82) for isolator detail.

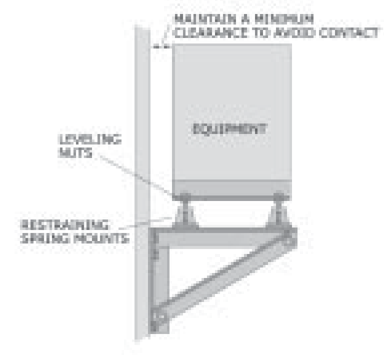


Figure 126: Wall-mounted, vibration-isolated equipment.

Step 1: Assemble wall frame with isolators

Accurately draw the bolt pattern on the wall using one of the following methods:

- Set the frame in place and mark the holes.
- Make a template.
- Use measurements and approved construction documents to lay out the bolt hole pattern.

Step 2: Install anchors

If anchoring to concrete, install post-installed anchors (see Anchors, page 104, or Masonry and Drywall Anchors, page 114).

Step 3: Attach isolators, rod, and hang equipment

Attach the isolators to the framing.

Raceways, conduits, and cable trays may now be connected.

END OF ATTACHMENT.

ANCHORS

General Anchors

IMPORTANT: Installation methods depend on the type of anchor and the particular application. Always follow the anchor manufacturer's installation instructions.

Figure 127: Types of anchors.

Some anchors shall not be used with vibratory loads.

Step 1: Determine the type of anchor

Using Figure 127 (page 104), identify the anchor recommended for your application. Anchors 1-6 are post-installed anchors and instructions for installing them begin on this page. Anchors 7-11 are specialty anchors and instructions are shown on pages 112 to 129.

The various steps for installing anchors into concrete, brick, and concrete block anchors are shown below.

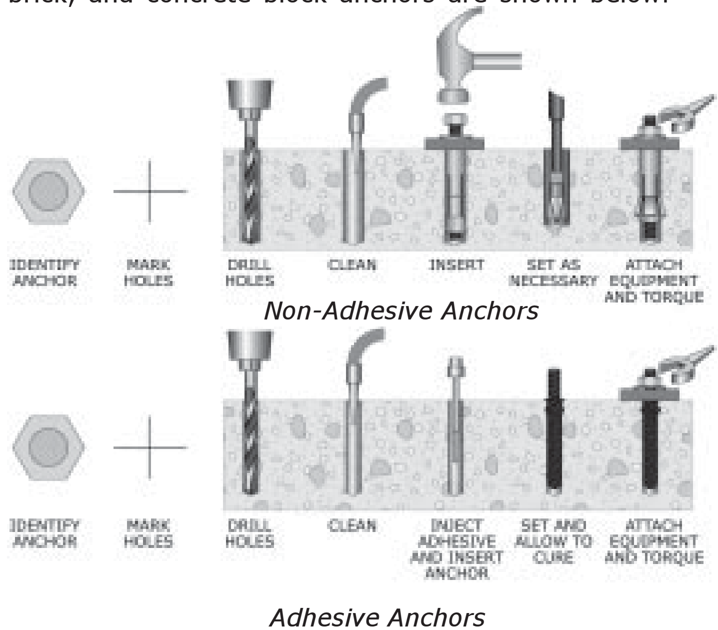


Figure 128: Summary of installation steps.

Approved construction documents may require special inspection to torque anchors or for proof load using hydraulic rams.

Step 2: Determine where to drill the hole

To determine anchor locations for the equipment you are installing, follow the instructions for the Attachment Type you are using (pages 51 to 103). Coordinate the equipment connections and hole locations with the location of any steel reinforcements or tendons.

Determine the depth and location of any steel reinforcement or tendons *before* drilling. This may require relocating equipment slightly to avoid the reinforcement.

FOR POST-TENSIONED (PRE-STRESSED) BUILDINGS, LOCATE THE TENDONS BEFORE DRILLING. EXTREME DAMAGE MAY OCCUR IF A TENDON IS NICKED OR CUT.

When using electronic locating devices to find reinforcement and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precision of the test unit and record the results. For example: *agreed upon mark +/- ¼" location vertical, horizontal, and depth +/- ½".*

Coordinate the location of anchors with the edge of the concrete, construction joints, and other anchors.

Do not install the anchor too close to the edge of the concrete base. Typically the anchor's distance from the edge is 1½ times the embedment depth.

Do not install an anchor too close to another anchor. Typically the minimum spacing between anchors is two times the anchor's embedment depth.

Step 3: Drill the hole

Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.

Do not drill holes into concrete at an angle.

For wedge, undercut and sleeve anchors, drill the hole deeper than the required embedment depth.

The required hole depth may be different from the embedment depth. See Figure 129 (page 107).

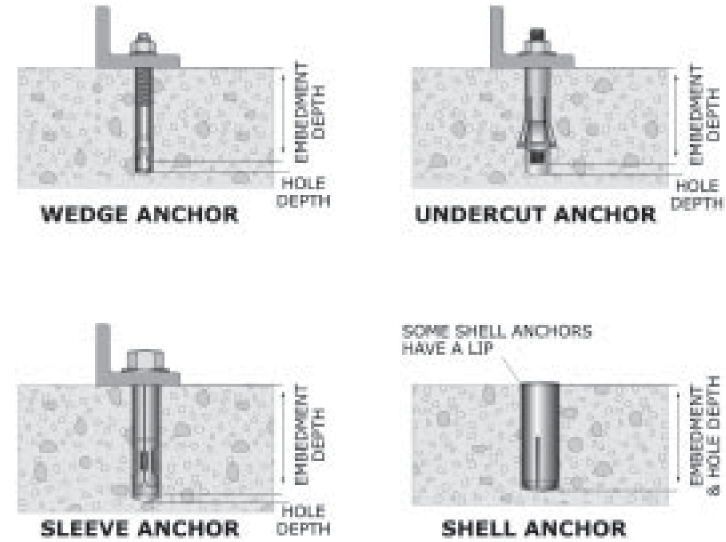


Figure 129: Embedment depth and hole depth of four anchor types.

The depth of the concrete base must be at least one inch greater than the hole you are drilling.

Some undercut anchors require an even deeper concrete base.

If you strike steel reinforcement when drilling, you must have the damage inspected. As directed, fill the hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see below).

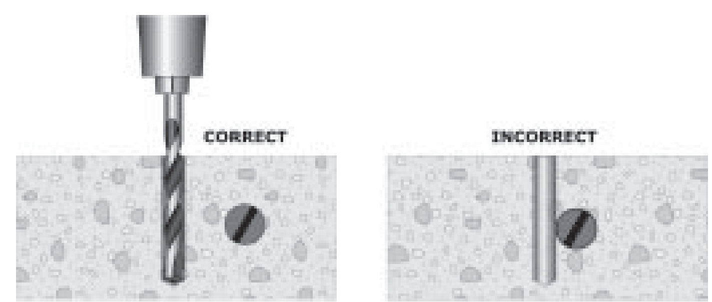


Figure 130: Drilling into concrete with rebar.

Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use a brush.

See the anchor manufacturer's instructions for cleaning the hole.

CLEANING IS IMPORTANT: a "dirty" hole can significantly reduce an anchor's performance.

Step 5: Insert the anchor

If you are installing any anchor *other than* an adhesive anchor, drive the anchor into the hole with a hammer or use a wrench rotor hammer for concrete bolts.

IMPORTANT: DO NOT DAMAGE THE THREADS DURING INSTALLATION. DO NOT FORCE THE ANCHOR. If you use a larger hammer than recommended by the manufacturer, you may damage the anchor.

If you are installing an adhesive anchor, insert the capsule or inject non-capsule adhesive into the hole. Slowly rotate the anchor into place as shown below.

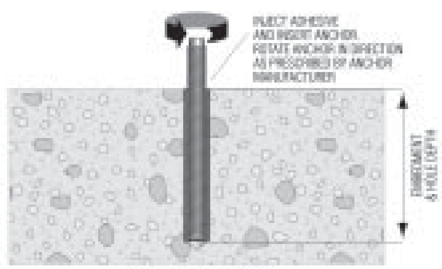


Figure 131: Adhesive anchor installation.

If you have installed a wedge or sleeve anchor, go to Step 7 (page 110).

Anchors: General

Step 6: Setting adhesive, shell and undercut anchors ONLY

Adhesive Anchor: Allow enough time for the adhesive to fully cure. The curing process may take a long time. See the manufacturer's instructions.

Shell Anchor: Drive the prescribed setting tool into the anchor until the setting tool shoulder meets the edge of the anchor, as shown below. See the manufacturer's instructions.

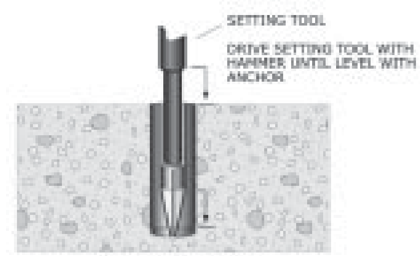


Figure 132: Set shell anchors.

Undercut Anchor: Use special tools provided by the anchor manufacturer to set the anchor, as shown below. See the manufacturer's instructions.

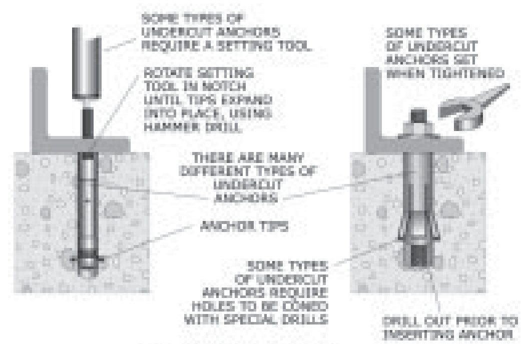


Figure 133: Set undercut anchors.

Step 7: Set the equipment and tighten the anchors

Set the equipment in place. Check for gaps. Gaps under the equipment must not be greater than 1/8” as shown below. If the gap is greater than 1/8”, dry pack the gap with grout and repeat this step.

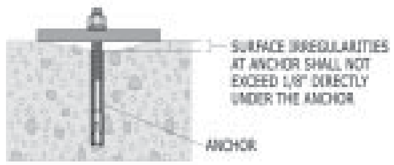


Figure 134: Acceptable gap for grouted plate.

For anchor bolts larger than 3/8”, the equipment housing should be reinforced using a structural angle bracket as shown in Figure 135 (below).

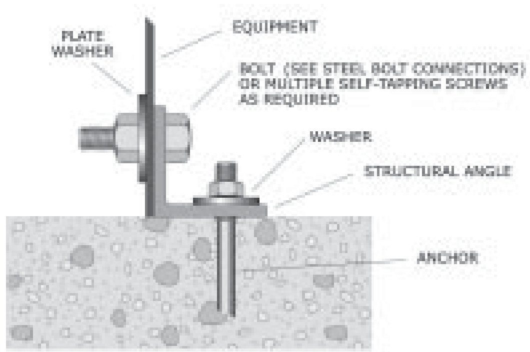


Figure 135: Installing a reinforcing angle bracket to equipment.

Tighten the anchor bolt to the correct torque setting in the manufacturer’s instructions or approved construction documents. Use a calibrated torque wrench.

END OF DETAIL.

Cast-in-place Anchors

Cast-in-place anchors are embedded in the concrete when the floors or walls are poured. Bolts are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the anchors can be determined from approved construction documents.

Step 1: Move the equipment into place

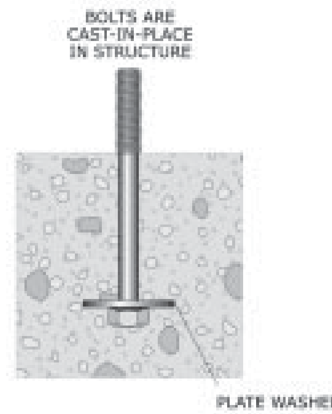


Figure 136: Bolting equipment to cast-in-place anchors.

Step 2: Secure equipment

Once the equipment is in place, apply washers and nuts and then tighten.

Tighten the anchor bolt to the correct torque setting in the manufacturer’s instructions or approved construction documents. Use a calibrated torque wrench or turn-of-nut method (see Table 14, page 124).

END OF DETAIL.

Lag Bolts

Lag bolts are used to attach equipment or steel shapes to wood structures. The size and location of the anchors can be determined from construction drawings (see Figure 137 below).

- The edge distance for the non-loaded side is 1½ times the bolt diameter.
- The edge distance for the loaded side is 4 times the bolt diameter.
- The spacing between bolts is 4 times the bolt diameter.
- The end distance is 7 times the bolt diameter.

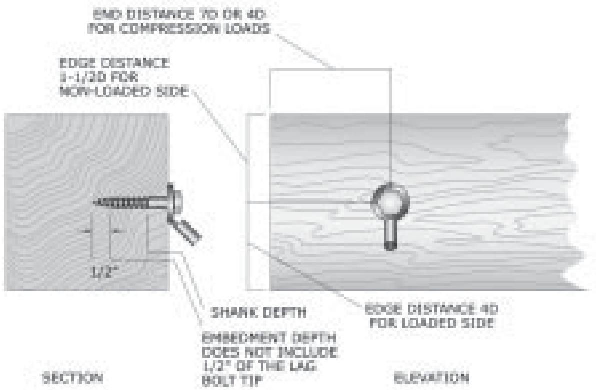


Figure 137: Spacing requirements for wood lag bolts.

Figure 137 is allowed for cable attachment. If a strut is attached to wood, both edge distances are considered loaded and require 4 times the bolt diameter.

Do not anchor to the end grain.

Step 1: Mark the location of the lag bolts

Lead holes and clearance holes are not required for lag bolts that are 3/8″ or smaller. If the lag bolt is smaller than 3/8″, go to Step 4.

Step 2: Drill a clearance hole

Drill a hole with a drill bit the same size as the shank of the bolt. The depth of the hole is the same as the length of the unthreaded shank that will extend into the wood (see Figure 137, page 112).

Step 3: Drill a lead hole

Drill a hole with a drill bit that is 60% to 70% of the diameter of the shank of the bolt. The depth of the hole is the same as the embedment depth of the bolt (see Figure 137, page 112).

Step 4: Move the equipment or steel shape into place

Step 5: Install the lag bolt with a wrench

You may use soap or other lubricant on the lag bolt.

DO NOT USE A HAMMER TO INSTALL LAG BOLTS.

Step 6: Tighten the bolt

Hand-adjust the lag bolt until there is firm contact between the lag bolt and connected metal components. Hand tools may be used to bring the lag bolt and metal components into contact. Following contact, tighten nut as shown in Table 14 (page 124).

END OF DETAIL.

Masonry and Drywall Anchors

Step 1: Determine the type of anchor

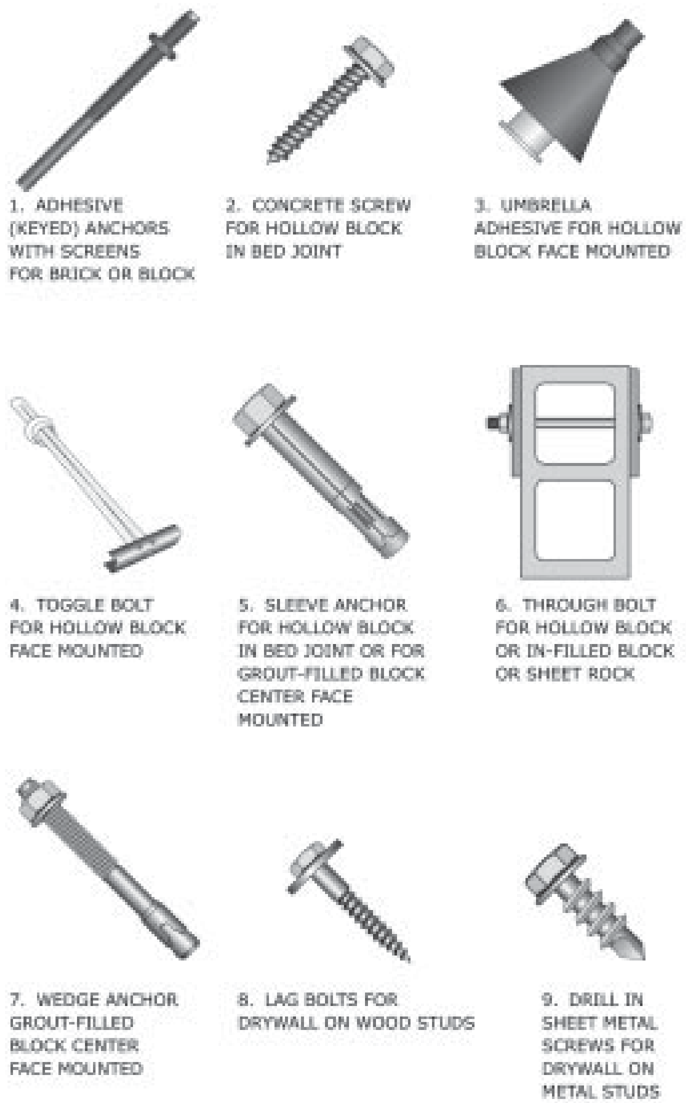


Figure 138: Types of masonry and drywall anchors.

Step 2: Determine where to drill the hole

Anchors shown in Figure 138 (page 114) must be installed in specific areas of hollow block and in-filled block. See Figure 139 (below) for approved anchor hole locations when using any of the concrete block anchors shown in Figure 138 (page 114).

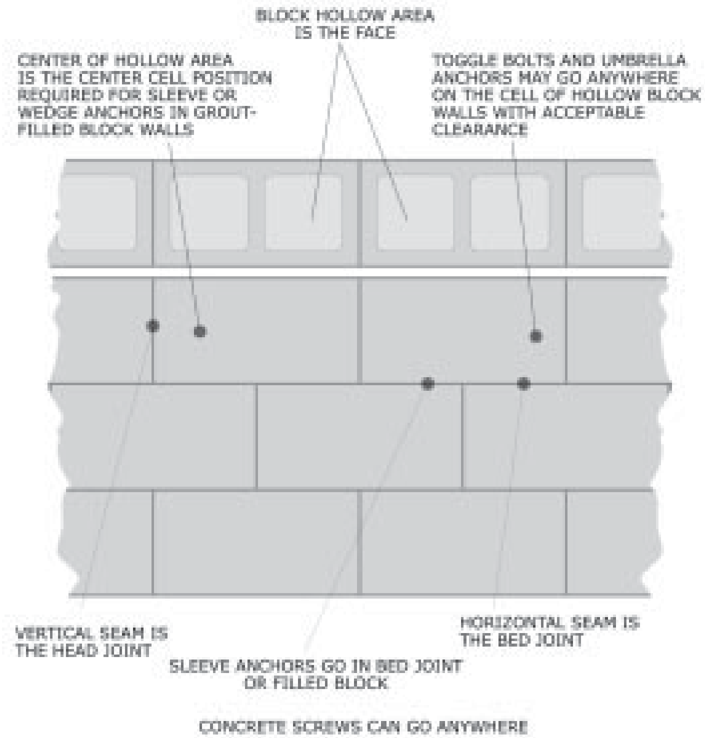


Figure 139: Block wall locations.

The location of the anchors should be coordinated with the block webs, or centered in the cell face, *and properly spaced from other anchors.*

DO NOT POSITION THE HOLES IN THE HEAD JOINT. Carefully note the location of anchors in the face location, centered face location, and bed joint as they apply to different anchors.

When installing through-bolts: avoid webs in block walls, reinforcements in grout-filled walls, and studs in drywall.

When installing lag bolts and sheet metal screws in drywall: install in a wood or metal stud as appropriate.

Determine the depth and location of any steel reinforcement in grout-filled block walls or brick before drilling. This may require relocating equipment slightly to miss reinforcement.

When using electronic locating devices to find reinforcements and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precision of the test unit and record the results. For example: *agreed upon mark +/- ¼" location vertical, horizontal, and depth +/- ½".*

Step 3: Drill the hole

Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.

Use masonry drill bits for brick and block.

DO NOT CUT STEEL REINFORCEMENT WHEN DRILLING HOLES.

If you strike steel reinforcement when drilling, you must have the damage inspected. As directed, fill the hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see Figure 130, page 107).

Holes for concrete screws are smaller than screw size. See the manufacturer's instructions for specific requirements.

Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use a brush.

See the anchor manufacturer's instructions for cleaning the hole.

CLEANING IS IMPORTANT: a "dirty" hole can significantly reduce an anchor's performance.

Step 5: Insert the anchor

The following anchors use different insertion methods.

- Adhesive screen anchor in a brick wall or hollow block wall (this page).
- Adhesive anchor in a hollow block wall (page 118).
- Concrete screw (page 119).
- Toggle bolt (page 119).
- Concrete anchor (sleeve anchor or wedge anchor) (page 120).
- Drywall anchor (lag bolts and sheet metal screws) (page 120).

Adhesive screen anchor in a brick wall or hollow block wall

See the anchor manufacturer's instructions before connecting the anchor to a brick or hollow block wall.

A screen insert is shown in Figure 140 (page 118). Insert the screen in the wall. Inject the adhesive. Slowly insert the anchor with a twisting motion.

Screens may be filled with adhesive before inserting the screen into the hole.

For details on installing adhesive anchors in a brick wall, see Figure 141 (page 118). Similar installation applies to hollow block walls. Adjust the anchor by hand while the adhesive sets.

DO NOT TOUCH THE ANCHOR WHILE THE ADHESIVE IS CURING.

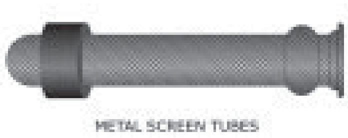


Figure 140: Brick/block wall insert.

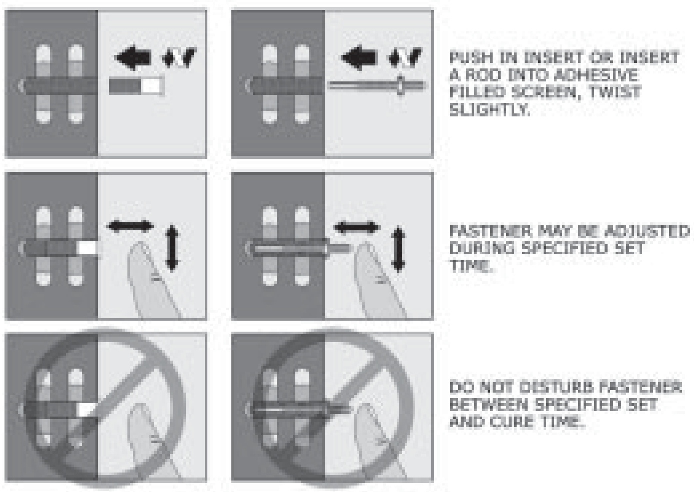


Figure 141: Brick wall adhesive anchor.

Adhesive anchor in a hollow block wall

See the anchor manufacturer's instructions before connecting the anchor to a hollow block wall.

Push an umbrella anchor into the hole until the umbrella unfolds in the block cavity. Inject adhesive into the umbrella. Slowly insert stud or fastener with a twisting motion.

DO NOT LEAK ADHESIVE ON THE THREADED PORTION OR CLEAN WITH SOLVENT. The threaded area must be free of debris to attach to a threaded rod or steel bolt.

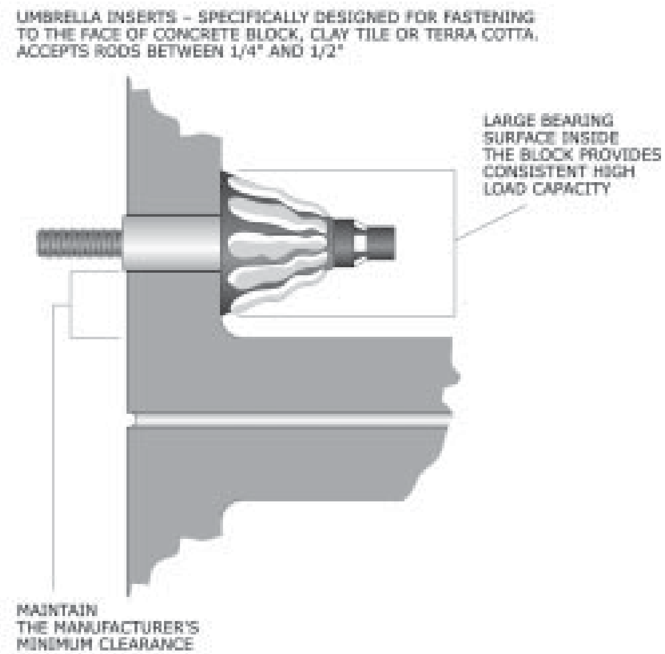


Figure 142: Umbrella anchor in a hollow block wall.

Concrete screw

Drill bits may be specifically sized for each manufacturer, and typically are smaller in diameter than the nominal or fractional diameter of a screw. Install a concrete screw with a rotary drill and bolt the head attachment.

Toggle bolt

Hold the toggle flat alongside the plastic straps and slide the channel through the hole. Slide the holding ring toward the wall until the channel is flush with the wall. Cut off the straps at the holding ring. Insert the bolt with a rotary drill over the bracket or equipment mounting (see Figure 143 on page 120).

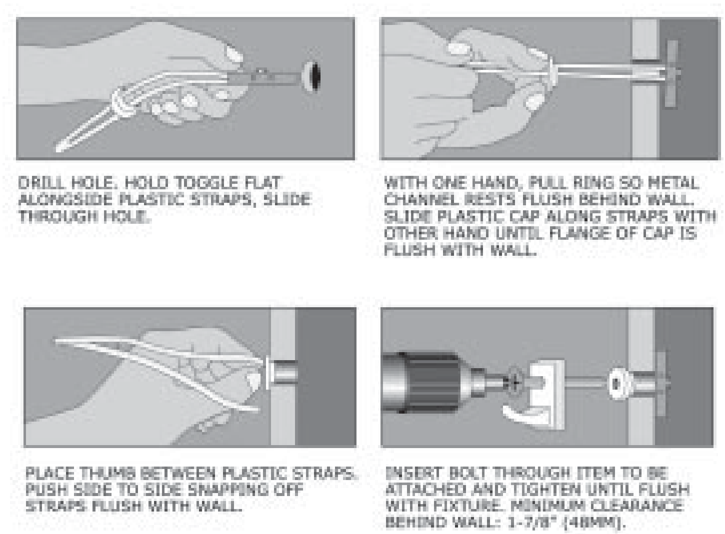


Figure 143: Toggle bolt installation.

DO NOT OVER-TIGHTEN.

Concrete anchor (sleeve anchor or wedge anchor)

Use a hammer to drive the anchor in the hole.

DO NOT FORCE THE ANCHOR. If you use a hammer larger than recommended, you may damage the anchor.

To determine the embedment depth of post-installed anchors, see Figure 129 (page 107).

Drywall anchor (lag bolts and sheet metal screws)

Use a rotary drill to insert the anchor.

DO NOT OVER-TIGHTEN.

Step 6: Set the anchor (adhesive only)

Allow enough time for the adhesive to harden and adhere to the concrete. *This may take several hours.*

Step 7: Set the equipment and tighten the anchors

Tighten the anchor bolt to the proper torque setting as shown in the anchor manufacturer's instructions or approved construction documents.

In-filled block walls may have gaps in the grout fill or the grout may slightly crack, requiring anchors to be installed in the center of the cell.

If the grout cracks severely, or if you miss a grouted block, the anchor will not tighten and will pull out. If it pulls out, move the anchor to a new centered cell location.

END OF DETAIL.

Power-Actuated Anchors

Step 1: Determine type of anchor

Figure 144: Two types of power-actuated anchors.

Authorities having jurisdiction may require a license to use power-actuated anchors.

Refer to the Anchor Selection Guide (page 151) for additional information.

Step 2: Determine where to place the fastener

Follow the manufacturer's recommendations for minimum slab thickness and best location.

Step 3: Install anchor

Using tools provided by the anchor manufacturer, install the anchor at the desired location. Follow all the manufacturer's instructions. Also see Power-Actuated information in the Anchor Selection Guide (page 151).

For threaded rods, follow Step 4.

When using drive pins, install the pin with the strap or wire to complete the installation.

Step 4: Set equipment and tighten

Tighten the anchor nuts over equipment brackets on the threaded rods.

END OF DETAIL.

Steel Bolt Connections

The three ways to attach bolted connections are:

- Connecting the base of the equipment to an angle bolted to a concrete floor (this page).
- Bolting two structural steel shapes together (page 125).
- Bolting a threaded rod to steel shapes or strut (page 126).

Connecting the base of the equipment to an angle bolted to a concrete floor

Step 1: Preparation

Determine the bolt size or sheet metal screw and material requirements from approved construction documents or the manufacturer's instructions.

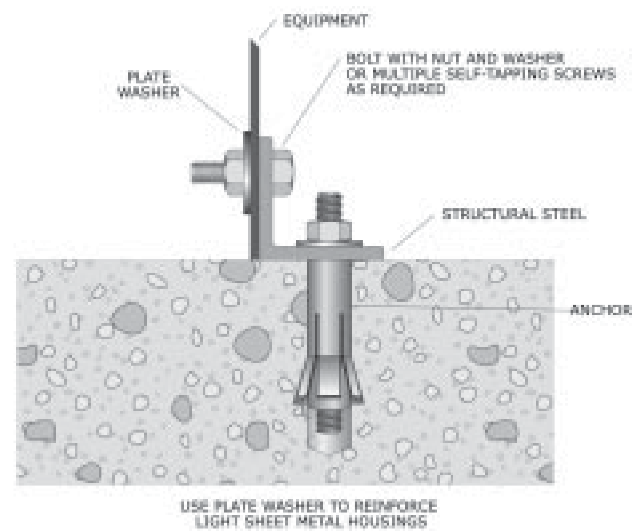


Figure 145: Bolting equipment to an angle.

Step 2: Locate attachment holes

It is preferred to use the holes provided by the manufacturer. Under supervisory approval, you may need to drill additional holes in the equipment assembly or building steel beams as shown on approved construction documents or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

Step 3: Install bolts, washers, and nuts

Once the equipment is in place, apply washers and nuts and then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents.

For turn-of-nut tightening, hand-adjust the bolt until there is firm contact between the bolt and the connected metal components. Hand tools may be used to bring the bolt and metal components into contact. Following contact, tighten the nut as shown below.

Length of Bolt	*Additional Tightening*
Up to and including 4 diameters	1/3 turn
Over 4 diameters and not more than 8 diameters	1/2 turn
Over 8 diameters and not more than 12 diameters	5/6 turn

Table 14: Turn-of-nut, hand-adjusted tightening.

Bolting two structural steel shapes together

Step 1: Preparation

Determine the bolt size and material requirements from approved construction documents or the manufacturer's instructions.

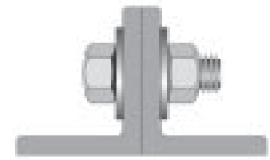


Figure 146: Bolting structural shapes.

Step 2: Locate holes

It is preferred to use the holes provided by the manufacturer. Under supervisory approval, you may need to drill additional holes in the equipment assembly or building steel beams as shown on approved construction documents or the manufacturer's instructions.

USE CAUTION WHEN DRILLING INTO EQUIPMENT. Internal components can be damaged or the manufacturer's warranty may be voided.

DO NOT DRILL OVERSIZED HOLES. New holes cannot be oversized or oval in shape. Repair oversized holes as shown in Figure 76 (page 54), if necessary.

Step 3: Install bolts, washers, and nuts

Apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents. Use a calibrated torque wrench or turn-of-nut method (see Table 14, page 124).

Bolting a threaded rod to steel shapes or strut

A threaded rod is used with suspended equipment. This section includes attachment to the equipment and attachment at the top (see Suspended Attachments, page 71).

Step 1: Preparation

Determine the threaded rod size from approved construction documents or the manufacturer's instructions.

The three different ways to attach the top connection of a threaded rod are shown in Figure 147 (below).

Step 2: Attach the top connection of the threaded rod

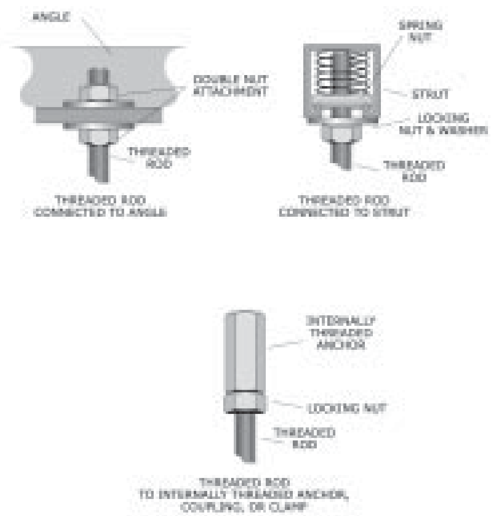


Figure 147: Attaching the top connection of the treaded rod.

Apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents. Use a calibrated torque wrench or turn-of-nut method (see Table 14, page 124).

Step 3: Attach treaded rods to equipment brackets

Equipment without attachment brackets require additional steel shapes for connections to the building structure and/or roof.

Once the equipment is in place, apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents. Use a calibrated torque wrench or turn-of-nut method (see Table 14, page 124).

END OF DETAIL.

Welding

Before welding, refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Attaching equipment to embedded plates: Plates are embedded in the concrete during the floor or wall pour. Plates are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the plate can be determined from approved construction documents. See Figure 148 (below) for weld locations.

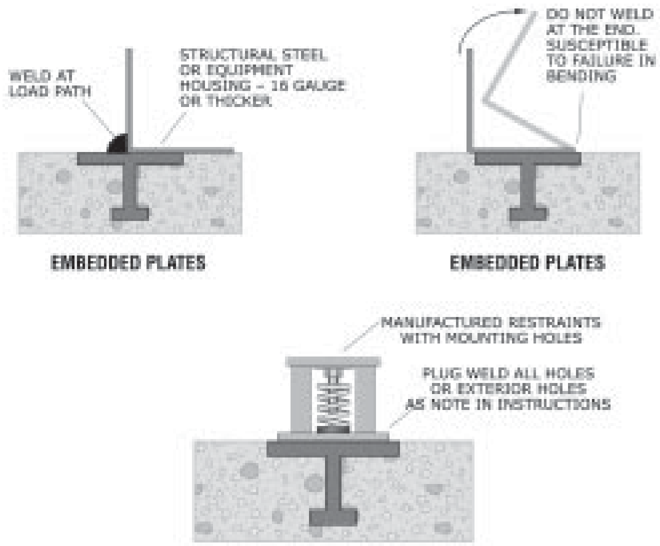


Figure 148: Welding to embedded plates.

Attaching structural shapes and plates: Shapes and plates are welded to provide equipment attachment. All weld base material must be thick enough for the weld size specified.

Step 1: Determine the weld material, shape, and dimensions for each piece

Step 2: Fit the material to ensure proper weld joint preparation

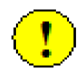
Step 3: Clean the surfaces

Surfaces must be dry and free of galvanized coating, hot-dipped or rust inhibitor, paint, scale, rust, oil, grease, water, and other foreign material for a minimum of one inch from the estimated toe of the weld.

Step 4: Weld the materials

The weld must be as prescribed in the welding procedure specifications (WPS).

WPS for shop and field pre-qualified weld joints and weld joints qualified by test must be prepared for review and approval before fabrication. All welding procedure items such as base metals, welding processes, filler metals and joint details that meet the requirements of AWS D1.1 will be considered prequalified. Any change or substitution beyond the range or tolerance or requirements for pre-qualification will be qualified by test per AWS D1.1.



DO NOT WELD OVER PAINT. You may paint after welding has cooled to room temperature.

Step 5: Inspect the weld

Make sure the surface is free of slag, dirt, grease, oil, scale, or other contaminants.

Welds cannot have cracks. Adjacent layers of weld metal and base metal must be thoroughly fused together.

All craters must be filled to the full cross-section except outside the effective weld length.

Underrun must not exceed 1/16". Undercut must not exceed 1/16" for any 2" per 12" weld or 1/32" for the entire weld.

Surfaces must be free of coarse ripples, grooves, abrupt ridges, and valleys. The faces of fillet welds must be flat or slightly convex.

END OF DETAIL.

Anchor Sizes for Equipment Weighing Less than 400 Pounds

Rigid floor-mounted equipment

Bolt equipment to a concrete floor or weld to a steel beam according to Table 15 (below). Install one anchor at each corner. Torque anchors according to the manufacturer's instructions.

Anchor	*Embedment (in.)*	*Minimum Edge Distance (in.)*
1/4" wedge	2"	3"
3/8" sleeve	1-1/4"	2"
1/8" weld	1" long at each corner	N/A

Table 15: Rigid floor-mounted anchor sizes.

These anchor/weld selections apply to equipment in which the height of the center of gravity (center of equipment mass) is less than twice the base length AND twice the base width.

Roof-mounted equipment

Anchor equipment to a concrete deck, a wood beam, or directly to a steel structural shape according to Table 16 (page 131). Install one anchor at each corner. Torque anchors according to the manufacturer's instructions.

Anchor	*Embedment (in.)*	*Minimum Edge Distance (in.)*
1/4" wedge	2"	3"
3/8" sleeve	1-1/4"	2"
3/8" lag	1-1/2"	1-1/2" to edge of wood and 3" from end
1/4" steel bolt	N/A	1/2"
1/8" weld	2" long at each corner	N/A

Table 16: Roof-mounted anchor sizes for rigid connections.

These anchor/weld selections apply to equipment in which the height of the center of gravity (center of equipment mass) is less than twice the base length AND twice the base width.

Suspended equipment

Rigidly suspend equipment from the building structure above with angles or rods and cables according to Table 17 (below and next page). Torque anchors according to the manufacturer's instructions.

Vertical threaded rod	*Quantity*	*Anchors per Rod*
1/2" rod with rod stiffener	One on each corner	1

Table 17: Suspended equipment anchor sizes for rigid connections *(table continued on next page)*.

Rod anchor	*Embedment (in.)*	*Minimum Edge Distance*
1/2" wedge	2-1/4"	3-1/2"
1/2" sleeve	2-1/4"	3-1/2"
3/8" lag bolt	2"	1-1/2" to edge of wood and 3" from end
1/2" steel bolt	N/A	1"

Cable	*Quantity*	*Anchors per cable*
1/8" seismic cable	4 at 45 degrees, one from each corner	1

Cable anchor	*Embedment (in.)*	*Minimum Edge Distance (in.)*
1/2" wedge	2-1/4"	3-1/2"
1/2" sleeve	2-1/4"	3-1/2"
3/8" lag bolt	2"	1-1/2" to edge of wood and 3" from end
1/2" steel bolt	N/A	1"

Table 17 *(continued)*: Suspended equipment anchor sizes for rigid connections.

END OF DETAIL.

SPECIAL CASES

Cables

The three ways to assemble a cable connection are by using:

- Bolts with center holes (page 134).
- Ferrule clamps (page 135).
- Wire rope grips (page 137).

Other end fittings may be acceptable.

Cables should be installed at a 45-degree slope. Where interferences are present, the slope may be a minimum of 30 degrees or a maximum of 60 degrees.

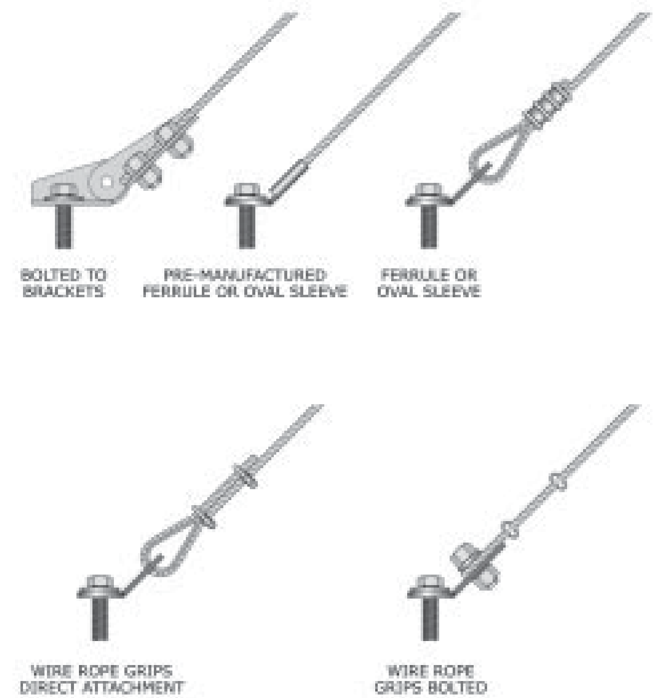


Figure 149: Cable attachments.

Bolts with center holes

The manufacturer provides this type of cable assembly, along with the cables, mounting bolts with holes, and brackets that attach directly to the building structure or equipment frame. Assemble the cable as shown below.

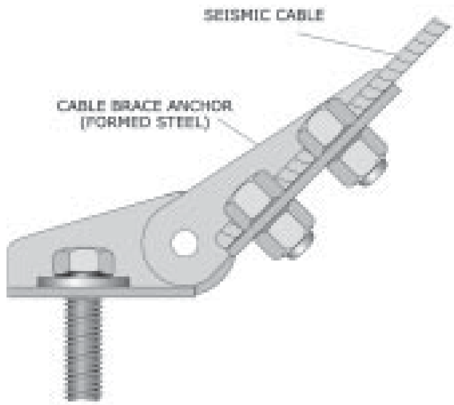


Figure 150: Cable attached with bolts to a bracket.

Step 1: Drill anchor holes in the building structure as required

Step 2: Attach brackets to both the building and the equipment frame

Step 3: Cut the cable to desired length and slide it through the holes in the bolts

Step 4: Tighten the cable

For rigid connections, pull the cable hand tight. For isolated components, pull the cable hand-tight and let out 1/8" slack. Avoid using too much tension or too much slack.

Step 5: Torque bolts

Torque bolts per manufacturer's recommendations.

Overtorque may damage cables.

END OF DETAIL.

Ferrule clamps

Ferrule clamps may be connected to various types of attachments. Figure 151 (below) and Figure 152 (page 136) show attachments and identify the parts (ferrules, sleeves, and thimbles) used in the assembly.

Ferrules must be made of steel, zinc-plated copper, or steel alloys (including stainless steel). Do not use aluminum ferrules.

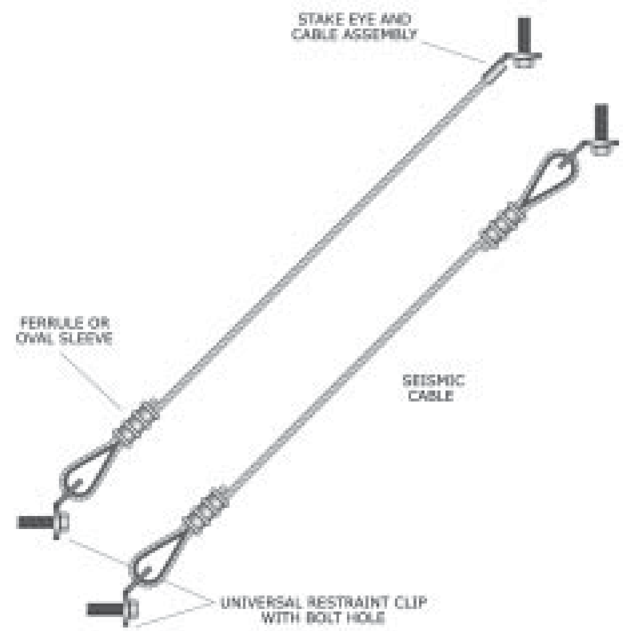


Figure 151: Ferrule assemblies.

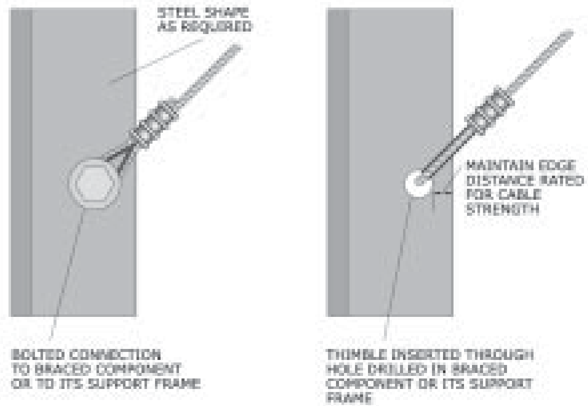


Figure 152: Ferrule attachments.

Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes

Install brackets with mounting holes to the structure. Attach cables to the top of cord angles. See Suspended Attachments (page 71).

Step 2: Cut the cable to the desired length and slide the oval ferrule (sleeve) onto the cable

Step 3: Wrap the cable around the thimble and pass it through the mounting bolt or holes and back through the ferrule

Step 4: Tighten the cable

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

Step 5: Crimp the ferrule or oval sleeve two or three times as specified in the cable or ferrule manufacturer's instructions

Use crimp tools and gauges specified by the manufacturer. Crimp and verify the depth of the crimp using a gauge.

END OF DETAIL.

Special Cases: Cables

Wire rope grips

Installing cables attached with wire rope grips is similar to attaching ferrule clamps, as shown below.

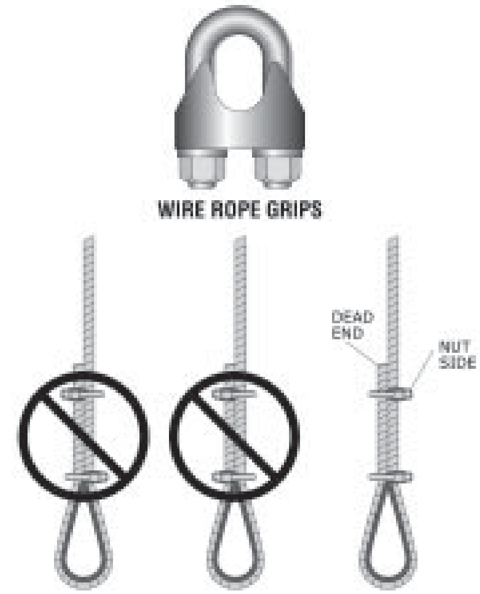


Figure 153: Wire rope grip assemblies.

Figure 153 clarifies the orientation of wire rope grips.

Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes

Step 2: Cut cable to the desired length and slide three wire rope grips and thimbles onto the cable

Step 3: Pass the cable through the mounting bolt or holes provided and then back through each of the wire rope grips

Use thimbles for all cable installations with wire rope grips.

Step 4: Tighten the cable

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

Step 5: Torque all bolts evenly

Use the turn-of-nut tightening method described in Step 3 of Steel Bolt Connections (page 124).

DO NOT OVER-TIGHTEN. See Table 14 (page 124).

END OF DETAIL.

Control Panels

Control panels may be built into units, mounted in a separate electrical panel attached to equipment assemblies, or mounted as a separate electrical panel attached to the building structure.

Be sure to refer to approved construction documents and specifications, seismic restraint submittals, and the manufacturer's instructions.

If an electrical panel is mounted separately from the unit and the unit is vibration-isolated, use flexible electrical connections to allow for differential movement.

Step 1: Select control panel support configuration

If the control panel is:

- Built into the equipment, no other action is needed.
- An electrical panel attached to the assembly, check that the attachment is rigid and tight. No other action is needed.
- A remote panel attached directly to the building structure or attached using support angles or struts, support the panel. The four ways of supporting control panels are by attaching them to:
  - An aluminum plate extending from the floor to the ceiling. The aluminum plate is attached to the floor and ceiling with angles, as shown on the left in Figure 155 (page 140).
  - A double-strut support spanning the floor and ceiling as shown on the right in Figure 155 (page 140). Struts are attached to the building structure with small angle clips.
  - Vertical angles or strut extending down to the floor with angles slanted back to the floor as shown in Figure 154 (page 140). This is the typical method. Details are shown in Figure 156 (page 141).
  - Walls with wall anchors as shown in Figure 157 (page 142).

Figure 154: Typical control panel support using angles. Additional angle supports may be required (see below).

Figure 155: Two different ways to support control panels: using a metal plate attached to floor and ceiling with steel angles (left); using struts extending to floor and ceiling (right).

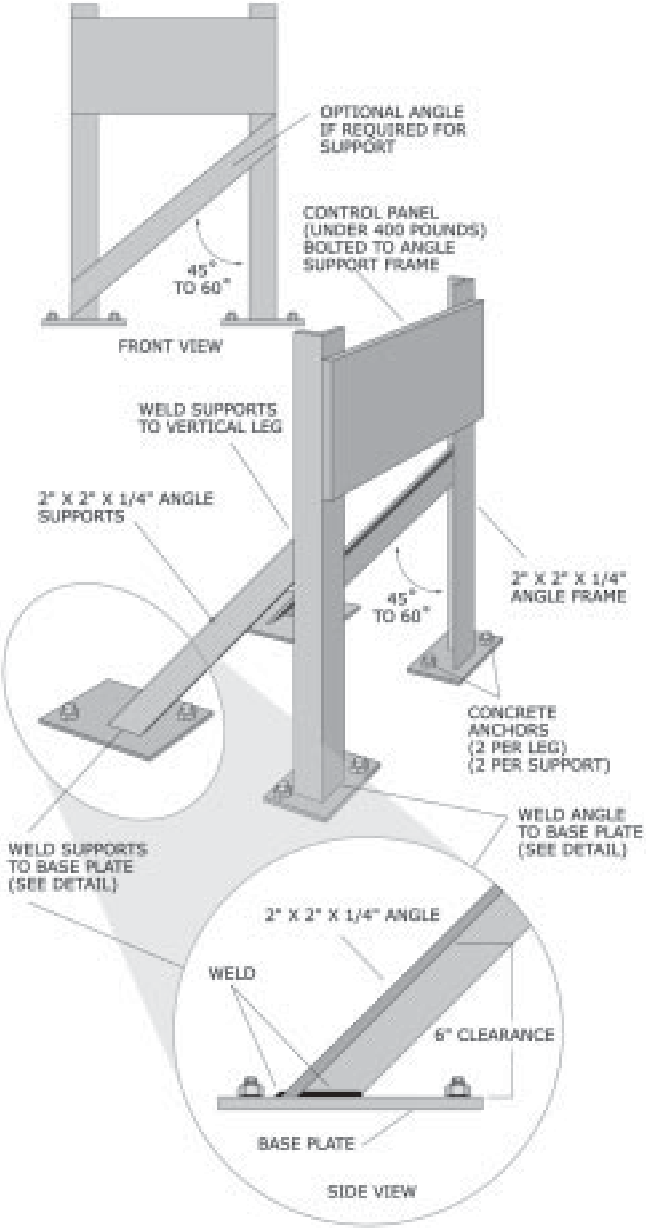


Figure 156: Angle assembly support from floor.

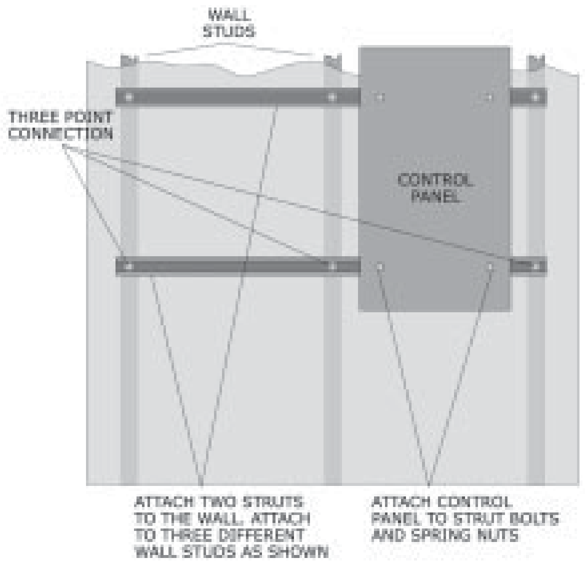


Figure 157: Direct attachment of a strut assembly support to wall.

Step 2: Assemble the mounting frame

Use bolts or weld the support framing together as shown in Figures 154 to 157 (pages 140 to 142). See Steel Bolt Connections (page 123), or Welding (page 128) for more information.

Step 3: Attach the mounting frame to floor or wall with anchors

Locate and mark hole locations in the building structure. Install the anchors. See Anchors (page 104) for more information.

Attach the mounting frame to the building structure.

- To attach strut angles for strut floor-mounted supports, see Figure 155 (page 140).
- To attach bases for angle floor-mounted supports, see Figure 156 (page 141).
- To attach strut to wall studs, see Figure 157 (above).

Step 4: Attach control panel to frame with a minimum of four steel bolts

See Steel Bolt Connections (page 123).

END OF DETAIL.

Housekeeping Pads

Be sure to refer to approved construction documents, specifications and the manufacturer's instructions.

The construction of housekeeping pads is shown below.

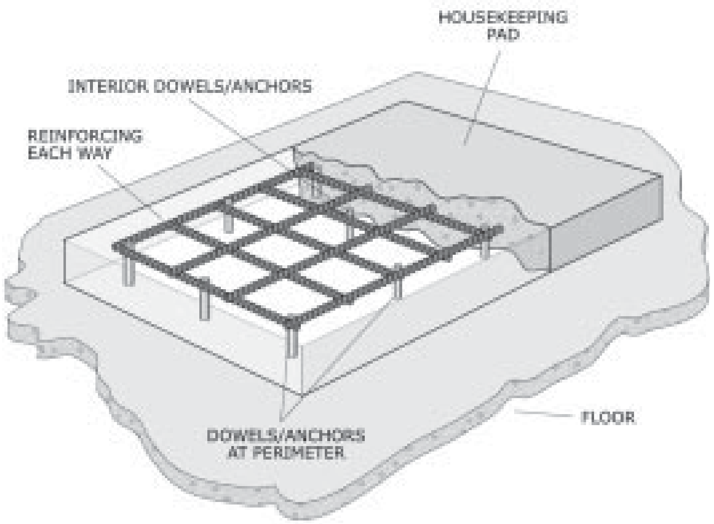


Figure 158: Housekeeping pad.

The housekeeping pad must be a minimum of one inch thicker than the anchor hole depth, or as required for the concrete anchors shown in Figure 159 (page 145).

Housekeeping pads must be designed for the equipment weight and seismic load.

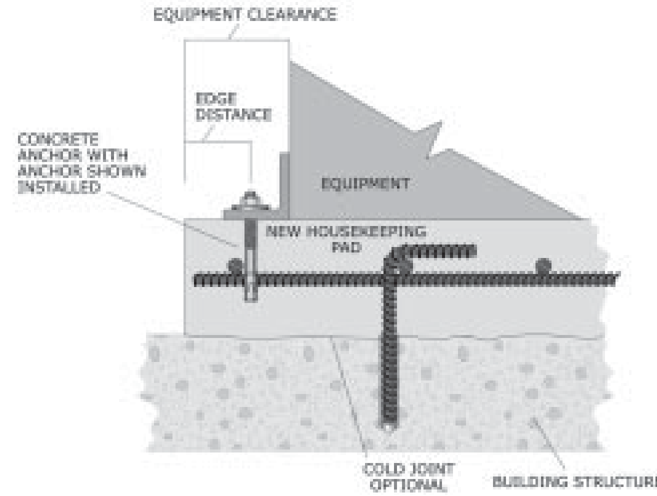


Figure 159: Housekeeping pad in section view.

If edge distance is not met, get an evaluation from your supervisor.

Dimensions for the housekeeping pad footprint must be large enough for the equipment, attachment steel (as required), and the edge distance of concrete anchors (see Anchors, page 104), as shown in Figure 160 (below).

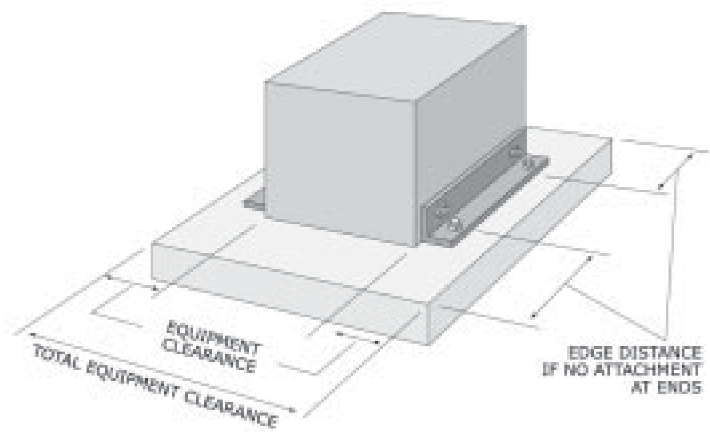


Figure 160: Housekeeping pad dimensions.

Step 1: Install dowels into the floor

Attachment details for dowels are shown in Figure 161 (below).

- Use measurements and approved construction documents to lay out the size of the dowels and the dowel pattern.
- Coordinate the location of embedded “Z” bar shown in Figure 161 with the concrete subcontractor.

Obtain the size of doweling and reinforcement from approved construction documents, specifications, or the manufacturer’s instructions. Exterior dowels must be ½” to 1” in diameter. Interior dowels must be ½” to ¾” in diameter.

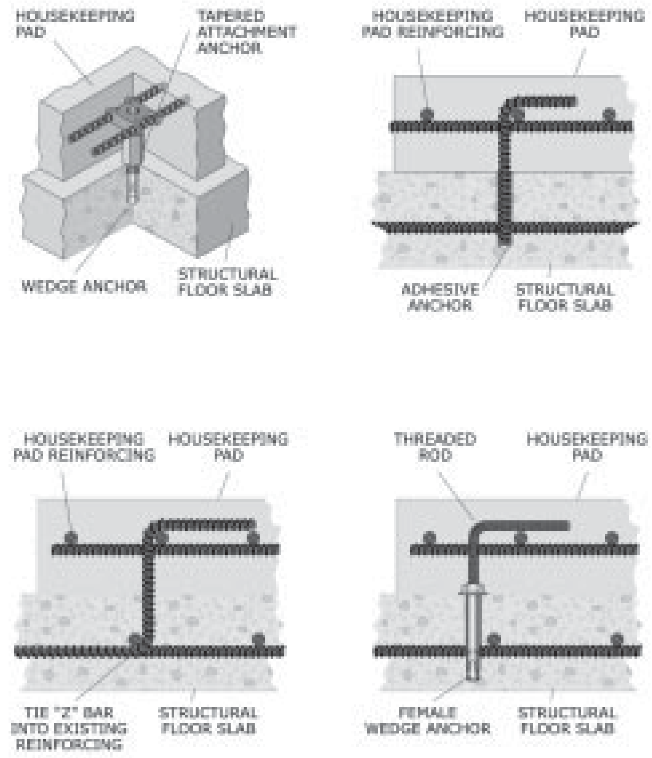


Figure 161: Doweling to the building floor.

Step 2: Assemble reinforcement

Assemble the reinforcement as shown in Figure 158 (page 144). Connect the dowels using wire.

Step 3: Pour concrete and allow to cure

Step 4: Drill holes and attach the equipment to concrete after the concrete has cured

END OF DETAIL.

Lighting

The three basic ways to attach lighting fixtures are:

- Directly to the building structure (this page).
- In suspended T-bar ceilings (page 149).
- Pendant-mounted (page 150).

Directly to the building structure

Step 1: Locate the attachment points

Use manufacturer's recommendation to attach the fixture to the building structure.

Use anchors to attach to masonry or concrete walls. Toggle bolts may be used for drywall construction if allowed by the approved construction documents.

Step 2: Attach the anchors to the building structure

Use brackets supplied by the manufacturer. See Anchors (page 104) for instructions on installing the anchors.

In suspended T-bar ceilings

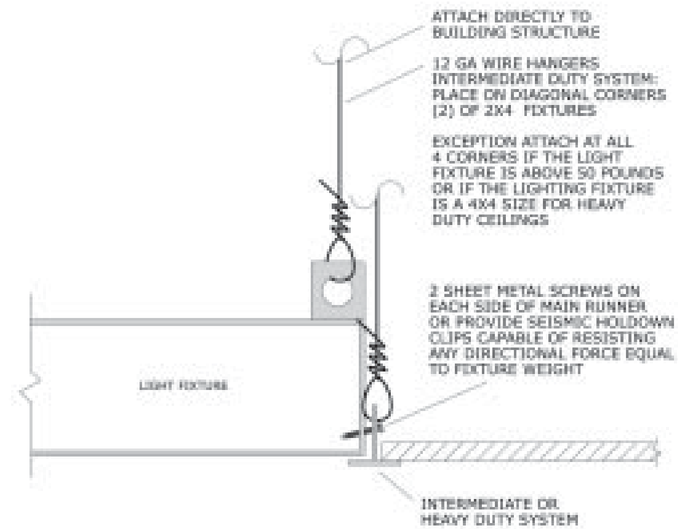


Figure 162: Typical ways to attach light fixturesin suspended T-bar ceiling.

Do not allow light fixture hanger wires to contact piping or ductwork as this may result in vibration or noise problems.

Install splay braces on lights as required by approved construction documents.

Step 1: Verify all T-bar ceiling runners are securely attached to the building structure as required by approved construction documents

This work is usually performed by a different subcontractor.

Step 2: Install lighting fixture into the T-bar ceiling runners

Step 3: Attach lighting fixture to ceiling runners using screws or clips rated for the weight of the fixture

Attachment to the T-bar ceiling can be made with screws as shown in Figure 162 (page 149) or with clips provided by the lighting manufacturer.

Step 4: Run wires directly from the light fixture and attach to the building structure with anchors.

For instructions on installing anchors, see Anchors (page 104). You may use power-actuated anchors if the anchors are rated for seismic use and have a tension rating (see Power-Actuated Anchors on page 122) .

Pendant-mounted

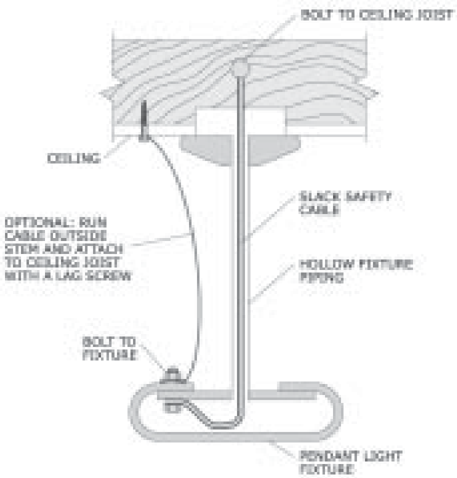


Figure 163: Pendant light fixture attachment

Step 1: Attach light fixture to ceiling

Step 2: Install safety cable

Safety cable should be bolted to light fixture and extended up to building structure. Safety cable may be internal to the fixture assembly or exposed.

END OF DETAIL.

ANCHOR SELECTION GUIDE

Power-Actuated	
Description	Warning
Threaded Studs Used in cases where the fastened equipment is to be removed later, or where shimming is required. Threaded studs for concrete have a 0.140" to 0.180" shank diameter, with typical penetration of 3/4" (mini-mum) to 1-1/2" into concrete. Threaded studs for steel plate applications have a 0.140" to 0.180" shank diameter when the steel plate thickness is 3/16" or greater.	**Safety is the primary concern when using power-actuated tools (PAT). PAT tools pose the greatest risk to the operator and others in the area of use. Observe the following safety precautions:** Typically not used for equipment weighing more than 40 pounds. Never allow a tool to be used until the operator is properly trained for the specific tool and application. Never use a tool unless all safety features are functioning properly. Always have the operator and others around wear personal protective equipment (PPE). Never use more powerful loads than required for the particular application. Always be aware of the potential of the fastener passing through the substrate or being deflected from its intended target. Make sure that all areas are clear behind and around the target area. Have an action plan in place to properly handle and dispose of misfired loads. Always make sure the tools are low velocity and not standard velocity. (Standard velocity tools are not typically allowed on most jobsites because of the danger.) **Authorities having jurisdic-tion may require a license to use power-actuated anchors.**
Drive Pins Used to directly fasten equipment for permanent installation. Drive pins used for concrete have a 0.140" to 0.180" shank diameter, with typical penetration of 3/4" minimum to 1-1/2" into concrete. Drive pins for steel plate applications have a 0.140" to 0.180" shank diameter when the steel plate thickness is 3/16" or greater.	

Adhesive	
Description	Warning
Capsule Spin-In Adhesive mixes in the hole when the anchor is drilled by a rotary hammer drill only. Various strengths and types of rods or fasteners can be used. Multiple types of coatings on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.	Do not over-spin during installation. The rod must have a roof cut end with a single or double 45-degree angle/bevel for mixing. The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong vapors during the curing process. Check the MSDS sheets or with your supervisor to determine if masks are required.
Capsule Hammer-in Adhesive mixes in the hole when the rod is driven by a hammer. Various strengths and types of rods or fasteners can be used. Multiple types of coatings on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.	The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong odors during the curing process. Check the MSDS sheets or with your supervisor to determine if masks are required.

Adhesive (cont.)	
Description	Warning
Epoxy Used by mixing two or more components with a mixing nozzle at the point of application. Can be used with multiple forms of fasteners or as an adhesive. Many brands can be used in wet, damp, or dry conditions. Many formulas are allowed for use for USDA food processing areas. Some may be able to be used overhead. Permitted many times in freeze-thaw and severe weather conditions. Allows minimal edge distance and anchor spacing. Typical shelf life greater than that of other adhesives used for anchoring. Not as susceptible to damage from high storage temperatures.	Typically requires long curing times compared to that of other adhesives. Can be virtually odor free or can emit a strong odor, depending on the formula. Can be difficult to apply if the epoxy is thick. Generally not suggested for use at temperatures below 32 degrees F. Most epoxies require holes to be cleaned to obtain maximum values. Check the MSDS sheets or with your supervisor to determine if masks are required.
Acrylic Adhesive Dispenses and cures quickly. Some adhesives can be used overhead. Some adhesives can be installed in damp or water-filled holes. Typically can be used with many fastening devices such as threaded rod, dowels, and anchors.	Many types of acrylics produce a strong odor during the curing process. Others have a minimal odor. Check the MSDS sheets or with your supervisor to determine if masks are required.
Adhesive Undercut Anchors Used in heavy-duty applications where substrate is of poor quality.	Generally purchased from the manufacturer as a complete anchoring system. Any substitution of materials must be authorized before installation.

Externally Threaded	
Description	**Warning**
Heavy Duty Undercut Used in heavy-duty applications. Typically two types: self-undercutting and adhesive. Self-undercutting types use a special undercutting drill bit similar to heavy-duty sleeve anchors except that they fill a cavity greater than the initial hole diameter.	May require special tools and specific drill bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.
Wedge Anchor The most common concrete anchor for heavy- to light-duty applications. Many configurations are available for most applications. Made from a variety of materials.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.
Heavy Duty Sleeve Anchor Expansion anchor for heavy-duty requirements.	A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If re-assembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or be detached from the expansion cone, requiring anchor replacement. These conditions are not visible.
Center Pin Anchor Medium-duty expansion anchor. The anchor is correctly installed when the pin is completely inserted. Installation procedures are simple; no torque is required to set the anchor.	Typically designed for static loads and not used with reciprocating engines, motors or in situations where vibrations are present.

Externally Threaded (cont.)	
Description	**Warning**
Sleeve Anchor Universal anchor for light- to medium-duty applications. Multiple head designs fit many applications and can be installed in masonry.	A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If re-assembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or be detached from the expansion cone, requiring anchor replacement. These conditions are not visible.
Concrete Bolts *(continued on next page)* Concrete bolts are recommended for use in dry interior applications. Concrete bolts may be acceptable in some cases for temporary use in exterior applications. Not all concrete bolts used in resisting earthquake or wind loads are appropriate and may be beyond the scope of the anchors abilities. Concrete bolts should not be subjected to vibratory loads such as those encountered by supports for reciprocating engines, crane loads, and moving loads.	Maintain equal or greater than minimum edge distance spacing specified for concrete bolts or apply reduction factors if applicable. The embedment depth is the distance from the concrete surface to the bottom of the screw anchor. Maintain minimum slab thickness. Use ONLY a specific manufacturer's recommended method of installation. NEVER substitute one manufacturer's concrete bolt installation instructions for another manufacturer's instructions. DO NOT ASSUME one manufacturer's instructions are the same as another manufacturer's instructions.

Externally Threaded (cont.)	
Description	**Warning**
Concrete Bolts (cont.) Concrete bolts are limited to installation in uncracked concrete masonry. Cracking may occur from anchor location in tension zone of concrete member, anchor location in setting concrete member, and anchors subjected to seismic loads, wind loads, or moving loads. Concrete bolts are limited to non-fire-resistive construction unless appropriate data is submitted demonstrating that anchor performance is maintained in fire-resistive situations.	Some manufacturers use different diameter drill bits for the same nominal diameter concrete bolt. Use the proper diameter drill bit before installation. When a specific screw anchor manufacturer's drill bit diameter is not used, a reduction of capacity must be accounted for in the calculations. Other manufacturers may *recommend* the use of ANSI B212 matched diameter drill bits for use with their concrete bolts. Some manufacturers may allow power tools for installation and others may not. Some screw anchor manufacturers recommend not using an electric impact wrench when re-using the same hole. Some manufacturers allow piloting a new anchor hole; 1 or 2 addition applications or re-uses are possible. If the manufacturer allows the screw anchor to be reused, inspect for excessive wear or the capacity of the screw anchor.

Anchor Selection Guide

Internally Threaded	
Description	**Warning**
Internally Threaded Undercut Anchor Used in heavy-duty applications. Typically come in two types: self-undercutting and those using a specialized undercutting drill bit. Anchors have internal threads. Shallow embedment and small edge distances and spacing are possible.	May require special tools and specific drill bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.
Shell Anchor Flush-mount or sub-surface internally threaded anchor for medium- to light-duty applications. Comes in fractional and metric sizes and is available in a variety of materials.	A special setting tool is required and must be supplied by the anchor manufacturer. The setting tool is designed for each anchor size and style.
Others Similar to the wedge concrete anchor and used in heavy- to light-duty applications. Many configurations are available to fit most applications. Made from a variety of materials.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.

Light Duty Fastenings	
Description	**Warning**
Drive Pin (nail) Anchors (metal and plastic) Light-duty anchor with fast and easy installation in many substrates.	Use only for static loads. Typically not used in overhead applications. **DO NOT USE FOR SEISMIC RESTRAINT**
Concrete Screws Medium- to Light-Duty A variety of lengths and diameters are available. Often used for temporary anchorage.	Typically not used in situations where extensive vibrations are present. Requires the use of a special drill bit (some metric) supplied by the anchor manufacturer.
Special Style Head Wedge (Ring) Anchor Wedge anchor with integrated connection (head) designed for tie wires or suspended ceilings.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.
Single and Double Expansion Shields Multi-purpose anchor used in concrete, Concrete Masonry Unit (CMU), brick, or stone. This anchor distributes fairly even pressure, making its use popular in CMU, brick, and natural stone. Typically used in conjunction with machine bolts, which can be removed and replaced.	Anchor material is malleable and the threads can be stripped. **DO NOT USE FOR SEISMIC RESTRAINT**

Light Duty Fastenings (cont.)	
Description	**Warning**
Lead Expansion Anchors Similar to expansion shields, but typically considered light-duty. Many can be used with a variety of screws or bolts. Quick and simple to install. Can be used in concrete, CMU, brick, or stone.	Anchor material is malleable and the threads can be stripped. Anchor should not be used in any applications. **DO NOT USE FOR SEISMIC RESTRAINT**
Toggle or "Molly"-type Anchors Light- to medium-duty anchor with easy installation in many substrates. No drilling is required for some anchor types or in some substrates. Some anchors are supplied with bolts or screws. Anchors are made from variety of materials and colors including plastic, zinc alloys, and steel.	May require a large hole. Anchor may or may not be reusable if the bolt is re-moved. Severe damage to the substrate can result if these anchors are removed after installation.

ELECTRICAL DANGER INSTRUCTION CHART

- Only qualified personnel familiar with proper voltage equipment are to perform work described in this set of instructions. Workers must understand the hazards involved in working with or near electrical circuits.
- Perform work only after reading and understanding all of the installation instructions in this manual and the manufacturer’s literature.
- Turn off all power-supplying equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm that the power is off.
- Beware of potential hazards. Wear Personal Protective Equipment (PPE) as required by NFPA-70E, and take adequate safety precautions.
- Replace all devices, doors, and covers before turning on the power to the equipment.
- All activities must be performed by qualified personnel in accordance with local codes.
- Precautions for circuit breakers:
  - The circuit breaker must be removed from its compartment and isolated from the voltage.
  - Control voltage must be in the open (O) position.
  - The circuit breaker must be in the open (O) position.
  - All circuit breaker springs must be discharged.
- Handle equipment carefully and install, operate and maintain it correctly in order for it to function properly. Neglecting fundamental installation and maintenance requirements may lead to personal injury, as well as damage to electrical equipment or other property.
- Heavy equipment should be stabilized with straps and other tie-downs to reduce the possiblity of tipping.
- Spreader bars must be evaluated by the appropriate design professional prior to lifting.
- When lifting, do not pass ropes or cables through lift holes. Use slings with safety hooks or shackles.
- Damaged vent housings can constrict proper air flow and expose the interior of electrical voltage compartment to weather.
- Do not make any modifications to the equipment or operate the system with interlocks and safety barriers removed. Contact your manufacturer’s representative for additional instructions if the equipment does not fuction as described in this manual.
- Complete seismic installation and proper inspection of work prior to enabling the circuit breakers.
- Use out-of-service tags and padlocks when working on equipment. Leave tags in place until the work is completed and the equpment is ready to be put back into service.
- Restore all seismic restraints removed for maintenance to their original installation configuration and torque all bolts/anchors to their proper values.
- Carefully inspect your work area and remove any tools and objects left inside the equipment.
- Remove all tools, lifting assembly, and miscellaneous items left on the equipment prior to enabling the circuit breaker.
- All instructions in this manual and provided by the manufacturer are written with the assumption that the customer has taken these measures before performing any maintenance or testing.

GLOSSARY

A

Adhesive anchor – A smooth or deformed steel bar or threaded rod, set in a predrilled hole in hardened concrete or masonry (including masonry units and mortar joints) that derives its holding strength from a chemical bonding compound placed between the wall of the hole and the embedded portion of the anchor.

Anchor – A device for connecting equipment and attachments to the building structure.

Attachments – Support systems used to connect equipment, pipe, conduit, or ductwork to the building.

Attachment type – Use of attachments to floors, walls, roofs, ceilings, and vibration isolators.

B

Bar joist – Ceiling joists supporting intermediate floors or roof made from steel angles and steel bars.

Base plate – A steel plate used for support and anchorage of an angle support or vibration isolator.

Bed joint – A horizontal seam in a brick or concrete block wall. Also see **Head joint**.

Bolt diameter – Thickness or width of the outside of the threaded portion of the bolt.

Building structure – Steel, concrete, masonry and wood members or surfaces that transfer the weight of the building and equipment to the ground.

Bumpers – Angles or other steel shapes with elastomeric padding rigidly mounted to the building structure in a pattern around the equipment base to limit horizontal movement.

Busbars – A conducting bar (usually made of copper) that carries currents to various electric circuits.

C

Cabinet – An enclosure designed for surface mounting or flush mounting that houses controls and electrical components.

Cable brace – A steel cable designed for use as a seismic sway brace for suspended equipment, conduit, cable trays or raceways. Also see **Pre-stretched cable.**

Cant strip – A material used to fill voids in roof flashing.

Cantilevered – A support member connected at one end and unsupported at the other end.

Cast-in-place – A steel shape embedded into concrete.

Cast-in-place anchor – A headed steel bolt set within a concrete form before concrete is poured.

Cold joint – An edge between two concrete surfaces.

Construction documents – Drawings, specifications, and manufacturer's instructions (approved by the appropriate design professional) that define the scope of a project and provide detailed information to seismically restrain the equipment, conduit, or raceways. Also known as blue prints.

Counter flashing – A light-gauge sheet metal folded support or equipment frame to shed water or snow onto the roof.

Curb – Raised or enclosed framework that supports equipment.

Cure – To gain internal strength over time to withstand external forces.

Cure time – The total time it takes for the material to be at an absolute full load capacity.

D

Design professional – The responsible party, recognized by the authority having jurisdiction, working within their scope of qualifications and providing design services.

Differential movement – The movement between two objects or surfaces.

E

Edge distance – The distance between a concrete anchor and the edge of a concrete surface or concrete cold joint.

Elastomeric – A material with flexibility in all directions that will return to its original shape if removed from its environment.

Elastomeric mount – A molded one-piece mount with surfaces designed to attach the equipment to the structure without metal-to-metal contact.

Elastomeric pad – A resilient natural or synthetic rubber-ike pad used to reduce sound, shock and high frequency vibrations.

Embedded plate – A steel plate set into concrete to permit a welded attachment.

Embedment – How far a post-installed anchor is inserted into a hole in concrete or wood after the anchor is set in place and torqued.

Embedment depth – See **Embedment**.

Enclosure – A case or housing to protect electrical components.

Equipment – Any mechanical or electrical component.

Expansion anchor – A post-installed anchor that uses some form of wedge or shell held against the edge of a drilled hole with friction.

F

Ferrule – A small metal tube that can be crimped around steel cables.

Fiberglass pad – A pad with a core of resilient fiberglass material covered by a moisture resistent resilient shell used to reduce sound, shock and high frequency vibrations.

Fillet weld – A type of weld between two pieces of steel where the welded surfaces are at right angles.

Flashing – Metal, asphalt, or elastomeric material with one or more layers surrounding a roof penetration specifically designed to weatherproof the building.

Flexible connector – A connector designed to allow slight movement between a piece of equipment, component, or system and another system in the event of an earthquake.

Flexible mounted equipment – A piece of equipment supported on or from a vibration isolator.

G

Gel time – A specified amount of time for an adhesive to form a jelly-like substance with strength to hold its own weight or the weight of a light steel anchor.

Grommet – A rubber or elastomeric bushing-shaped ring that may be used in restrained springs, snubbers, or with bolts to provide a cushioned or flexible connection.

H

Hand tight – The force applied by hand or with hand tools to bring two or more materials firmly in contact without a space.

Head joint – A vertical joint between two concrete blocks in a block wall or two bricks in a brick wall. Also see **Bed joint**.

Headed stud – A large bolt with a threaded shaft and a hexagonal-shaped bolt head typically used for embedment into concrete surfaces or in-filled masonry walls.

Height-saving bracket – A bracket used to accommodate the height of spring isolators without raising the equipment base more than a few inches.

Housed spring – A spring isolator with steel guides usually separated by an elastomeric sheet located on two opposite sides of the spring.

Housed spring isolator – A steel coil spring designed to be loaded in compression along the axis of the spring. Housed springs have a two-piece housing and mounting stud for the purpose of leveling equipment. The housing has limited lateral restraining capabilities and cannot resist uplift.

Housekeeping pad – A concrete pad under equipment that raises the elevation of the equipment above the building structure or structural slab.

I

Inertia base – A heavily weighted base, usually made of concrete, that weighs more than the equipment it supports.

In-filled block – A concrete block wall whose cells are reinforced with rebar and filled with a sand-grout mixture.

Isolators – See **Vibration isolators.**

L

Leveling stanchions – See **Stanchions.**

Load path – Seismic support of equipment and internal components that can be traced though connections and support steel to the building structure.

Load transfer angles – Angles bolted to equipment and to the building structure, transferring the weight and earthquake load through the angles to the building structure.

Longitudinal brace – A brace that restrains pipes, ducts, or raceways parallel to the longitudinal direction of the pipe, duct run, or raceway.

O

Open spring – A spring isolator with a bolt attachment at the top of the spring for connecting to equipment without any horizontal support.

Open spring isolator– A steel coil spring designed to be loaded in compression along the axis of the spring. Open springs have a plate or cup on the bottom and top with a mounting stud.

Oversized holes – Bolt holes greater than standard bolt holes allowed by industry standards.

P

Pad-mounted – Equipment mounted on a concrete structure not normally part of the building structure.

Plug weld – The weld of a plate or base plate to another metal surface where a plate is perforated with one or more holes, which are then filled with the weld filler material.

Point load – Weight and seismic forces that are focused to a single point connection to the building structure.

Post and beam – An elevated structure usually made from beams resting on posts or stanchions connected to the building structure.

Post-installed anchor – Anchors installed after the concrete has reached its specified strengh.

Post-tension (pre-stressed) building – A concrete building structure surface with internal steel cables that are stretched and restrained to permanently compress the concrete surface.

Pre-manufactured curb – A sheet metal curb manu-factured at a factory and sent to the job site.

Pre-manufactured vibration isolation curb – A factory-built curb designed to attach equipment to a roof and containing vibration isolators, which allow for slight movement of the equipment.

Pre-stressed beam – A concrete beam bonded to steel in tension in the form of a beam.

Pre-stretched cable – Cable that is stretched after it is manufactured.

R

Raceway – A channel (conduit or open raceway) designed to hold wires and cables or busbars.

Rated spring deflection – The dimension that a spring will compress when the weight of equipment is applied.

Rehabilitation – A new installation within an existing facility.

Restrained elastomeric mount – An elastomeric mount with an integrated seismic restraining mecha-nism that limits movement in all horizontal and vertical directions.

Restrained spring – A vibration isolator containing a spring enclosed in a welded or bolted steel housing that limits movement of the spring equipment attach-ment in all directions.

Restrained spring isolator – A steel coil spring designed to be loaded in compression along the axis of the spring. Restrained springs have a housing with integrated seismic restraining mechanisms, that limit movement in all horizontal and vertical directions.

Rigid-mounted equipment – Equipment solidly braced or bolted directly to the building structure without vibration isolation.

S

Screen – A tube of steel wire mesh used as an adhesive anchor for anchoring to block or brick walls.

Seismic cable – A galvanized steel or stainless steel braided rope that is pre-stretched.

Seismic restraint device – An attachment device designed to restrict movement of equipment during an earthquake.

Seismic restraint submittals – Documents created by contractors or vendors describing the means and methods for installing seismic restraint devices and submitted for design approval.

Seismic rod clamp – A clamping device for attaching rod stiffeners to a vertical threaded rod.

Seismic separation joint – A space provided between buildings or portions of a building to prevent contact caused by differential movement during an earthquake. For piping, ductwork and conduits crossing the seismic joint, the systems are connected with a flexible component that allows for differential movement at least twice the width of the seismic separation joint.

Self-drilling – A special type of concrete shell anchor with cutting teeth for drilling into concrete.

Self-tapping – Either a sheet metal screw with blades on the end (similar to a drill bit), allowing the screw to drill a hole and embed itself into a steel shape, or a concrete screw with a point and specially designed threads allowing the screw to grip the concrete and embed itself into the concrete.

Set time – The specific time required for material to harden when a light load may be applied.

Shallow concrete anchor – Any anchor with an embedment depth measuring less than 1/8th of its diameter.

Sheet metal curb – A square or rectangular box made from galvanized steel sheets used to connect equipment to a roof.

Shim – A thin wedge of material used to fill a space.

Snubber – A seismic restraint device used on isolated systems with an air gap and elastomeric bushing or oil-filled hydraulic cylinder (shock absorber) restricting the rapid motion of a pipe.

Snug tight – The force applied by hand or with hand tools to bring two or more materials firmly in contact with one another without a space.

Solid brace – A steel angle or strut channel designed for use as a seismic sway brace for suspended equipment, piping, ductwork, conduit, cable trays, or raceways.

Spring-isolated – See **Vibration-isolated.**

Stanchions – Columns or short structural steel shapes placed vertically that connect to equipment bases or horizontal structural steel frames to provide equipment support.

Structural steel shapes – A manufactured steel component in a variety of shapes.

Strut – A manufactured steel shape in various U-shaped patterns and sizes.

Strut frame – Steel framing made from strut members that act as a support to transfer the equipment weight to the building structure. See **Strut**.

Sway brace – Solid braces or cable braces that provide seismic restraint.

T

Tendons – Steel cables used in post-tension buildings. Also see **Post-tension building.**

Thimble – A metal spacer used on a cable to protect it from being bent and damaged.

Toe of the weld – The edge of a fillet weld.

Torque – A turning force around a bolt applied by twisting a bolt head or nut so the components will not separate.

Transverse brace – A brace that restrains pipes, ducts, or raceways perpendicular to the longitudinal direction.

Turn-of-nut method – A process to properly torque a bolt without a special tool like a calibrated torque wrench. See **Hand tight** and **Snug tight**.

V

Vibration-isolated – Allows flexible motion between equipment, piping, ductwork, conduit, cable trays, or raceways and the building structure.

Vibration isolators – Components containing resilient elements such as steel springs, air springs, molded pre-compressed fiberglass or elastomeric pads used to separate vibrating equipment, piping and ductwork from the building structure.

W

Web – A thin metal strip in a structural steel shape.

Weld base material – The material composition of an item being welded.

WPS – Weld Procedure Specification is required for all welding in accordance with American Welding Society D1.1. The WPS defines the essential variables and their limits for the weld and must be in the vicinity where the weld is occurring.

INDEX

A

acceptable gap 110
anchor 104-132, 162
    adhesive 104, 105-110, 117, 118, 151-153, 162
    cast-in-place 72, 104, 111, 163
    concrete bolt 104
    concrete screw 114, 119
    drywall 114-121
    embedded plates 104
    externally threaded 154-156
    gap 110
    general 104
    internally threaded 157
    lag bolts 104, 112-113, 114, 120
    light-duty fastenings 158-159
    masonry 104, 114-121
    non-adhesive 104, 105-110
    post-installed 73, 105
    power-actuated 122, 151
    sheet metal screw 114, 120
    shell 104, 105-110
    sizes for equipment less than 400 pounds 130-132
    sleeve 104, 105-110, 114, 120
    steel bolt 104, 123-127
    through-bolt 75, 116
    toggle bolt 114, 120
    umbrella 114, 119
    undercut 104
    wedge 104, 114, 120
    welding 128-129
anchor selection guide 151-159
angle 30-33, 35, 37-39, 43-44, 47, 49, 56-58, 60, 78-80, 83-84, 100, 110
attachment type 51-103, 162
    rigid floor-mounted/pad-mounted 51-64
        see also rigid floor-mounted/pad-mounted attachment
    roof-mounted 65-70
        see also roof-mounted attachment
    suspended 71-86
        see also suspended attachment
    vibration-isolated/floor-mounted 87-97
        see also vibration-isolated/floor-mounted attachment
    wall-mounted 98-103
        see also wall-mounted attachment
automatic transfer switches 4-5

B

bar joist 74, 77, 162
base
- inertia, concrete-filled 94, 96, 165
- plate 31, 35, 162
- round 58

battery racks 26-27
block walls 115
brace 32-33, 43-45, 47, 49, 100, 162
bracket 32, 81, 94, 98, 110
bumpers 89, 162
bypass-isolation switch 4

C

cable 38, 41, 45, 49, 63, 71-78, 162
- attach using 38, 41, 45, 49, 63, 71, 76-78, 81, 83-85, 133-138
- bolts with center holes 134-135
- ferrule clamps 135-136
- wire rope grips 137-138

cable trays 30-50 *see also* raceways
capacitor banks 14
cast-in-place anchors 72
- bolting equipment to 111

chain 86
circuit interrupters 16
clamp 32-33, 43-45
clevis hanger 36-42
concrete
- bolt 104
- drilling 107
- joint 60
- pouring 54, 147
- screw 114, 119
- slab 73

conduit 30-50 *see also* raceways
control panels 139-143
curb 15
- isolation 166

curing 109, 163

D

disconnects 18-19
dowel 146
drywall anchor 114-121

E

elastomertic pads 96-97
electric unit heater 28-29
electric water heater attachment 101
electrical danger instruction chart 160
embedded plates 58, 104, 128, 163
embedment depth 107, 164
equipment 4-29, 164
- automatic transfer switches 4-5
- battery racks 26-27
- control panels 6-7
- generators 8-9
- less than 400 pounds, anchor sizes for 130-131
- lighting 10-11
- load centers 12-13
- low voltage: substations, capacitor banks, switchboards, and switchgears 14-15
- medium to high voltage: switchgears, circuit interrupters, substation circuit breakers, and walk-in enclosures 16-17
- meters and disconnects 18-19
- motor control centers and variable frequency drives 20-21
- mutli-media racks 22-23
- panelboards 12-13
- setting/moving in place 54, 59, 64
- transformers 24-25
- typical 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29
- type of installation 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29
- uninterruptable power supplies 26-27
- unit heaters and tanks 28-29

F

ferrule clamps 135-136, 164
flashing 65, 67, 68, 70, 164
floor-mounted
- anchor sizes for 130
- attachments *see* rigid floor-mounted/pad-mounted attachments
- automatic transfer switches 4-5
- capacitor bank 14-15
- circuit interrupter 16-17
- computer rack 22-23
- control panels 6-7
- equipment rack 22-23
- generators 8-9
- low voltage switchboard 14-15
- media equipment 22-23
- meter center 18-19
- motor control center 20-21

floor-mounted continued
open multi-media rack 22-23
panelboard 13-14
substation 14-17, 24-25
switchgear 14-17
transformer, dry-type 24-25
uninterruptable power supply 26-27
unit heaters and tanks 28-29
flush-mounted
control panel 6
light 10
load center 12
frame 53, 81

G

gap *see* acceptable gap
generators 8
grouted plate 110

H

head joint 165
hole
cleaning 108
clearance 112
depth 107
drilling 106
lead 112
oversized, repair of 54
housekeeping pad 144-147, 165

L

lag bolts 104, 112-113, 114, 120
lighting 10-11
load centers 12-13
low voltage: substations, capacitor banks, switchboards, and switchgears 14-15

M

masonry and drywall anchors 104, 114-121
medium to high voltage: switchgears, circuit interrupters, substation circuit breakers, and walk-in enclosures 16-17
meters 18-19
motor control center 20-21
multi-media racks 22-23

O

oversized hole, repairing 54

P

pads 89
pad-mounted *see also* rigid floor-mounted/pad-mounted attachment
generator 8-9
substation 16-17, 24-25
transformer 24-25
panelboard 12-13
plate 38, 84, 128-129
post and beam 65-67, 167

R

raceways 30-50
supported from the floor 31-34
supported from the wall 34-35
suspended using clevis hanger braced at the restraining bolt 36-38
suspended using clevis hanger braced at the hanger rod 39-40
suspended using clevis hanger and 4-way cable brace 41-42
suspended using pipe clamps 43-46
suspended with a trapeze support system 47-49
crossing seismic joints 50
raised floor 61-64, 167
rebar 107
repair oversized holes 54
rigid floor-mounted/pad-mounted attachment
anchors sizes for 130
beneath a raised floor 61-64
directly to the floor/pad 51-55
using additional structural steel shapes 55-59
using bumpers to restrict horizontal movement 60-61
rods 36-40, 43-49, 71-81, 83-85, 125-127
roof-mounted attachment
anchor sizes for 130-131
to a wood frame 68
using leveling stanchions—post and beam 65-67
using restrained springs on leveling stanchions 69-70
rubber mounts 89

S

safety switches 18
screen insert 117-118
seismic
    cable 83, 84
    joint 50
sheet steel 52
snubbers 88, 94-97, 168
special cases
    cables 133-139
    control panels 139-143
    housekeeping pads 144-147
    lighting 148-150
spring
    housed 87, 165
    isolator 82, 83, 90-97
    open 87, 94-97
    restrained 69-70, 88, 90-93, 103, 167
stanchion 65-67, 69-70
steel beam 53
steel bolt connections
    bolted to a concrete floor 51-55, 123-124
    bolting two structural shapes together 125
    bolting a threaded rod to steel shapes or strut 55 ,59, 100, 125-127
steel shape 100-102, 128
strap 33-35
structural framing 53, 100-102
strut 30-33, 35, 37-39, 43-47, 49, 78-80, 168
substations 14, 16
suspended attachment
    anchor sizes for 131-132
    chain mounted 86
    double rod attachment—bolted to the building 84-85
    isolated using threaded rods and horizontal cable supports 81-83
    rigid using 4 threaded rods with horizontal cable supports 71-78
    rigid using angle/strut supports 78-80
switchboards 14
switchgears 15, 16

T

t-bar ceilings 149-150
tanks 28-29
tendons 30, 169
thimble 137, 169
torque 43-45, 61, 138, 169
transformers 24-25
transverse supports 30, 32, 33, 37, 39, 43, 47
trapeze support 47-48
turn-of-nut method 124, 169

U

uninterruptable power supplies 26-27
unit heaters 28-29

V

variable frequency drives 20-21
vibration-isolated/floor-mounted attachment
    on elastomeric pads with isolated anchors 96097
    on open isolators combined with snubbers 94-97
    on restrained isolators 90-93
vibration isolators 87-97, 102-103

W

walk-in enclosures 14
wall-mounted attachment
    directly to the wall 98-99
    to additional structural shapes 100-102
    vibration-isolated 102-103
webs 169
weld 45, 55, 57, 59, 65-66, 70, 92, 93, 100, 128-129, 169
wire rope grips 137-138
wood beam 73
wood frame 68

Z

"Z" bar 146

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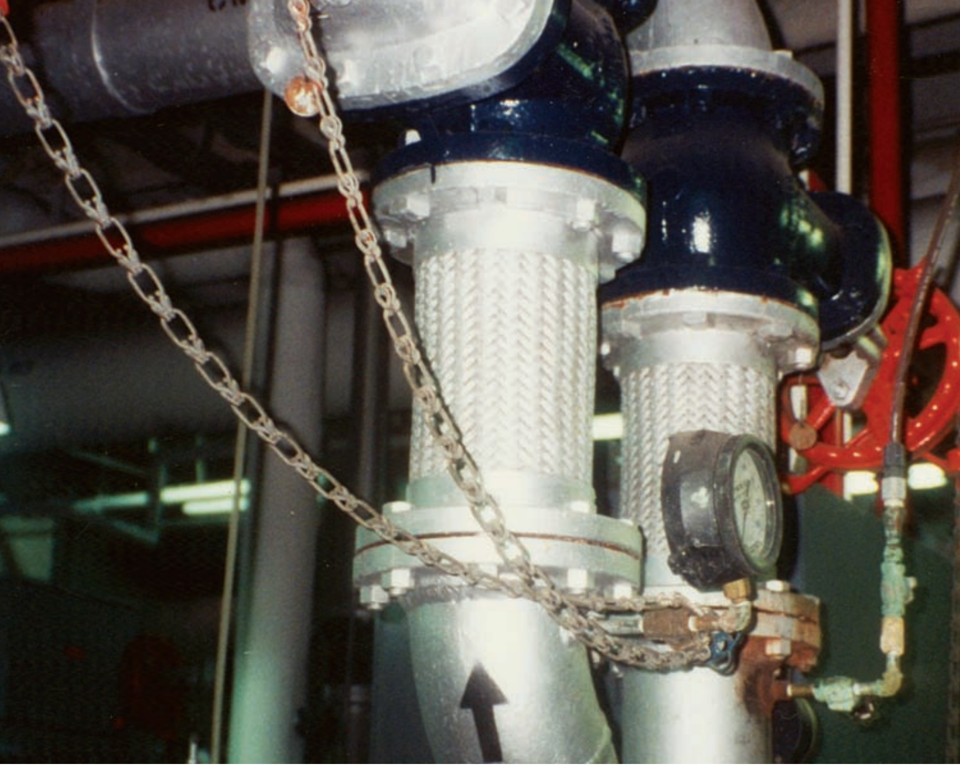

Installing Seismic Restraints for Duct and Pipe

FEMA P-414/January 2004

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VISCMA

Vibration Isolation and Seismic Control Manufacturers Association

ASCE

American Society of Civil Engineers

Developed by the Vibration Isolation and Seismic Control Manufacturers Association under a cooperative agreement between the Federal Emergency Management Agency and the American Society of Civil Engineers

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TABLE OF CONTENTS

INTRODUCTION **1**

DUCT AND PIPE BRACING LAYOUT **3**

DUCT/PIPE/IN-LINE EQUIPMENT BRACING SELECTION **8**

Duct Bracing Selection 8
In-line Duct-mounted Equipment Bracing Selection 10
Pipe Bracing Selection 12
In-line Pipe-mounted Equipment Bracing Selection 14

DUCT BRACING DETAILS AND INSTALLATION INSTRUCTIONS **16**

Suspended Rectangular Ducts 16
Suspended Round Ducts 28
Floor-mounted Ducts 41
Roof-mounted Ducts 44
Wall- and Chase-mounted Ducts 47
Duct Penetrations 50

PIPE BRACING DETAILS AND INSTALLATION INSTRUCTIONS **54**

Suspended Piping 54
Floor-mounted Piping 70
Roof-mounted Piping 73
Wall-mounted Piping 76
Pipe Penetrations 79

SUSPENDED EQUIPMENT ATTACHMENT **84**

Suspended by Threaded Rods Connected to Equipment Brackets or Additional Steel Supports 84
Suspended by Steel Shapes 95
Suspended by Threaded Rods for In-line Pipe Equipment 97

ATTACHMENT DETAILS CONNECTING TO BUILDING STRUCTURE **102**

ANCHORS **107**
General Anchors 107
Cast-in-place Anchors 114
Lag Bolts 115
Masonry and Drywall Anchors 117
Power-Actuated Anchors 125
Steel Bolt Connections 126
Welding 131
Anchor Sizes for Suspended Equipment 133

SPECIAL CASES **134**
Cables 134
Flexible Connections and Expansion Joints 140
Valves and Valve Actuators 144

ANCHOR SELECTION GUIDE **148**

GLOSSARY **157**

INDEX **166**

INTRODUCTION

This guide shows installers how to attach ducts, pipes, and associated equipment to a building to minimize earthquake damage. Many attachment examples and arrangements are presented, including anchors and the use of special devices called *seismic restraint devices.*

Seismic restraint devices include vibration isolation systems, cable or strut suspension systems, roof attachment systems, and the use of steel shapes.

Please note that this guide does not replace:

- Printed instructions shipped with the equipment.
- Instructions in construction documents and specifications. Use approved construction documents.
- Code-required, industry accepted practices.
- Safety guidelines and practices.
- Orders from your supervisor.
- Seismic restraint device submittals.

Please note that this guide does not include fire protection sprinkler, smoke and fire stops, or fire detection governed by local codes and the National Fire Protection Association.

If you have questions about any information in this guide, check with your supervisor.

This guide contains these sections:

- *Bracing Layout and Selection:* Organized by duct and pipe components.
- *Bracing Details and Installation:* Organized by duct and pipe components. Gives instructions on installing bracing in many different arrangements.
- *Attachments:* Contains instructions on attaching suspended equipment and attachment details that typically apply to connecting ducts and pipes to building structures.
- *Anchors:* Shows many different types of anchors used to connect equipment to a building.
- *Special Cases:* Covers cable assemblies, and special situations involving seismic joints, valves and valve actuators.

To use this guide:

1. Use the Table of Contents to find the Equipment section that best represents the equipment you are installing.
2. Using the table (see example below) in the Equipment section, find the:
   - type of equipment you are installing in column 1
   - method of installing the equipment in column 2
   - attachment type in column 3.

column 1	column 2	column 3
Typical Equipment	*How is equipment to be installed?*	*Attachment Type*
Any type of unit	Connected to angles mounted to the floor	Rigid with angles *Go to page 53*

3. Turn to the page referenced in column 3 for the equipment/attachment type you have selected. If you are not sure which attachment type is correct, ask your supervisor.
4. Follow the instructions for the attachment type you have selected. These instructions will refer you to the correct anchor section so you can make the connection to the building structure.

NOTE: All instructions in this guide are arranged in order using numbered steps. Please follow every step in the sequence shown.

Special precautions are marked:

A flag means you should take special care before continuing. Read all the information next to a flag before making the attachment.

A warning sign means you can cause serious damage to the building, the device, or the equipment if you do not follow the instructions exactly.

A book means you should refer to the manufacturer's printed instructions before continuing.

Note that a Glossary and an Index are also available to facilitate use of this guide.

DUCT AND PIPE BRACING LAYOUT

Be sure to refer to approved construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions. Also, refer to the manual that was used to design the seismic bracing. This manual is required to be on the job site.

Refer to approved construction documents that show the overall layout of the duct and pipe runs throughout the building. Normal vertical supports are provided at intervals as defined in codes and standards. Additional seismic bracing may be required.

Hanger and bracing locations are found in approved construction documents. Contact your supervisor to obtain these construction documents. When additional seismic bracing is required, follow the steps in this section to identify where you should place the additional bracing. Then turn to the page showing the details and installation instructions for each type of seismic brace.

Exceptions for ducts and piping: Refer to codes and manufacturer's manuals.

Refer to adopted local codes for any requirements that must be met to exclude seismic bracing.

Refer to local codes for hanger spacing requirements.

Step 1: Lay out supports or refer to drawings

A run is a single straight section of duct or piping. Any change in direction is considered a new or different run. Offsets within a run may be allowed if the offset is less than the recommended spacing divided by 16 or as allowed by approved construction documents.

Separate the layout into runs as shown in Figure 1.

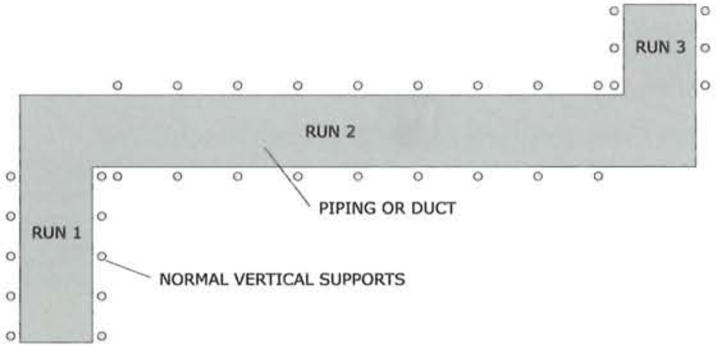


Figure 1: Separate layout into runs.

For bracing a single pipe run, there may be many short sections of pipe. Single or multiple offsets may be allowed if the total offset is less than the recommended transverse spacing divided by 16.

Offsets are shown in Figure 2.

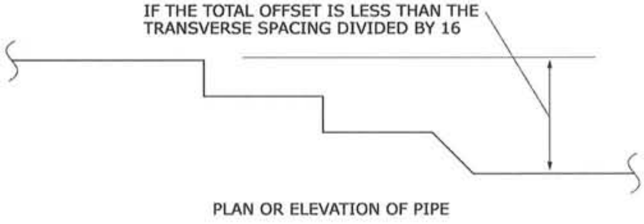


Figure 2: Pipe offset exception.

Step 2: Lay out transverse bracing

At a minimum, transverse bracing must be located at each end of the run as shown in Figure 3.

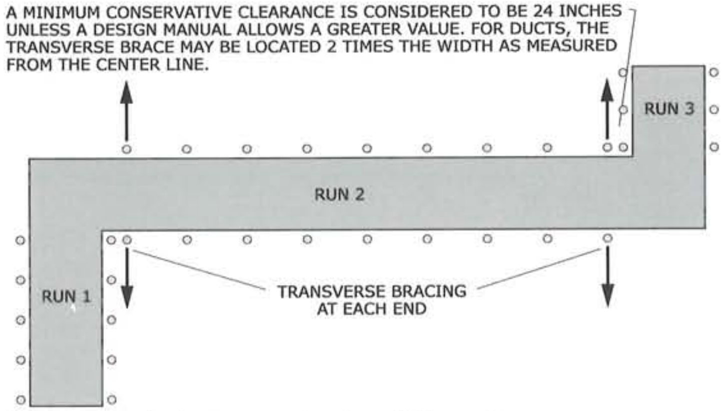


Figure 3: Locate transverse bracing at the ends.

Step 3: Check to see if additional transverse bracing is required

Refer to the bracing manual at the job site.

If the length of the run is greater than the allowed transverse spacing in the bracing manual, add intermediate transverse bracing until the spacing is correct as shown in Figure 4.

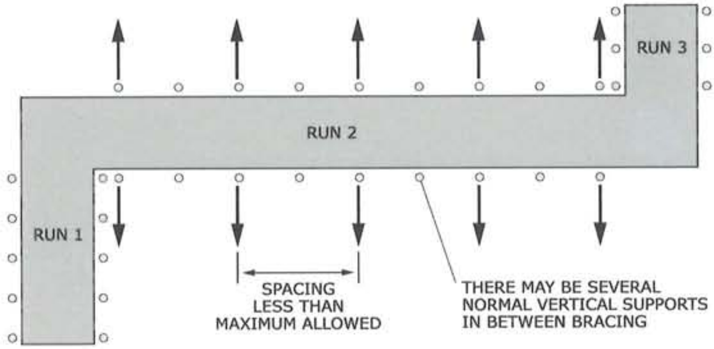


Figure 4: Install additional transverse bracing as necessary, to stay within maximum transverse spacing limitations.

Step 4: Add longitudinal bracing

Each run must have a minimum of one longitudinal brace as shown in Figure 5.

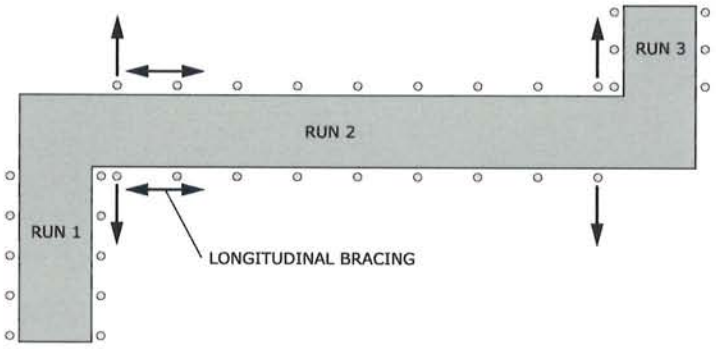


Figure 5: Add longitudinal bracing as necessary.

Transverse bracing on adjacent runs may be considered the longitudinal bracing as shown in Figure 6.

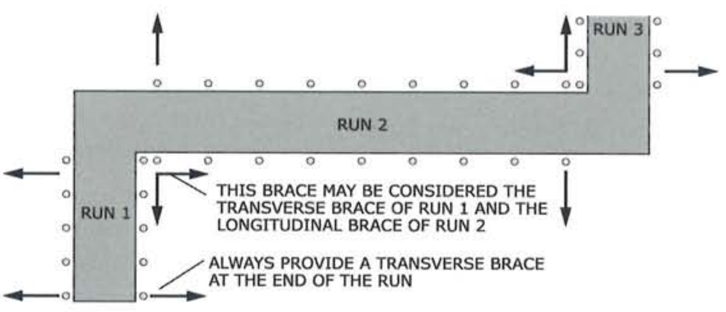


Figure 6: One cost-effective way to rearrange bracing.

Longitudinal bracing is usually spaced at a maximum distance that is two times the transverse spacing. For long runs, every second transverse brace should also have a longitudinal brace, as shown in Figure 7 (page 7).

Sometimes longitudinal bracing may be required on every transverse brace for large ducts and pipes.

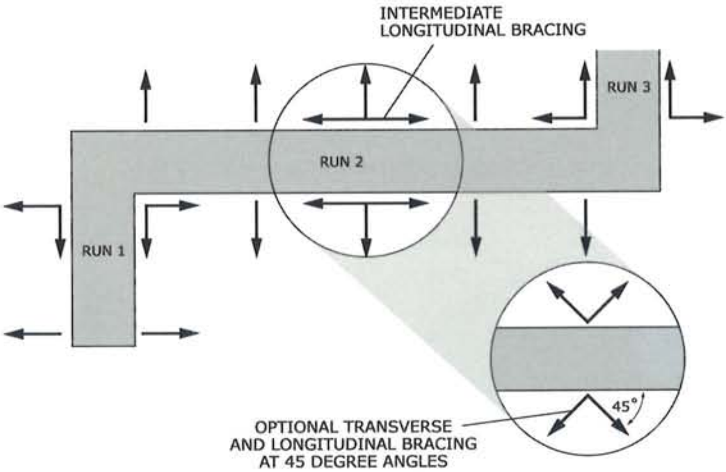


Figure 7: Final configuration.

Refer to the manufacturer's/industry manual for bracing requirements as designated in approved construction documents.

Refer to Figure 67 (page 63) for optional transverse and longitudinal bracing.

All longitudinal-only bracing must be physically attached to pipe. Attaching clevis-type hangers are not acceptable.

Go to pages 8-15 to select the bracing type for typical installations. Bracing details start on page 16.

DUCT/PIPE/IN-LINE EQUIPMENT BRACING SELECTION

Duct Bracing Selection

Be sure to refer to approved construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the duct bracing used

Figure 8 shows the different ways to brace ducts.

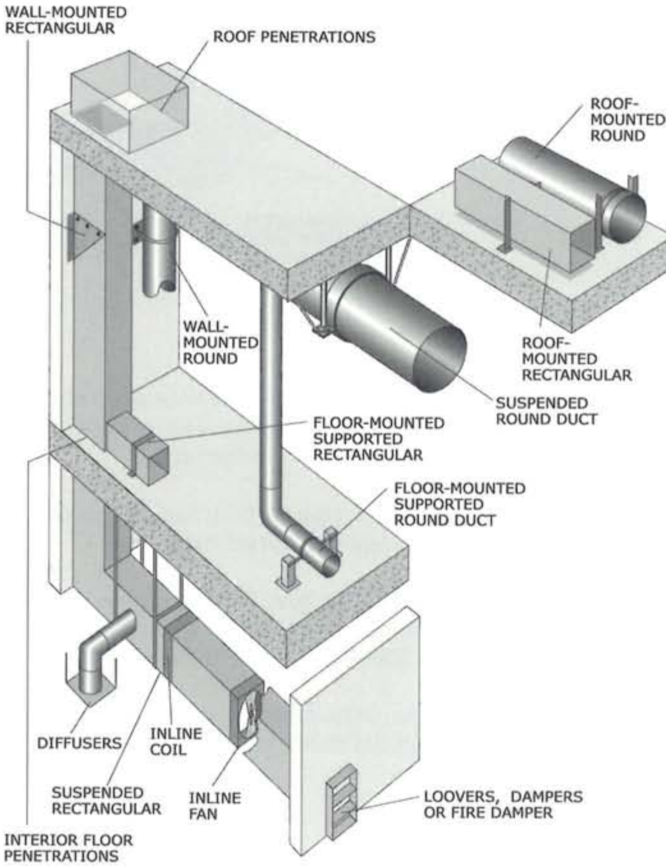


Figure 8: Duct system with different seismic braces.

In-line duct-mounted equipment can be found on page 10.

Step 2: Select the bracing type

Using the following table, select the attachment that best matches the installation you have selected, then turn to the page listed under the bracing type.

Typical Arrangements	*How is equipment to be installed?*	*Bracing Type*
Suspended rectangular duct	Suspended with rods or angles using cables or rigid laterals	Suspended rectangular ducts *Go to page 16*
	Isolated with rod supports and cable bracing	Vibration-isolated rectangular ducts *Go to page 26*
Suspended round duct (including oval duct)	Suspended with rods or angles using cables or rigid laterals	Suspended round ducts *Go to page 28*
	Isolated with rod supports and cable bracing	Vibration-isolated round ducts *Go to page 39*
Floor-mounted rectangular and round duct	Suspended off the floor with angles	Floor-mounted ducts *Go to page 41*
Roof-mounted rectangular and round duct	Suspended above the roof with angles	Roof mounted ducts *Go to page 44*
Wall-mounted rectangular and round duct	Supported off the wall	Wall mounted ducts *Go to page 47*
Duct penetrations	Ducts through building structure	Duct Penetrations *Go to page 50*
In-line duct-mounted equipment	Attached to the building structure	In-line duct - mounted equipment *Go to page 10*

Table 1: Duct bracing installation types.

Refer to approved contract documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers and seismic separation joints.

Refer to approved contract documents for re uirements for weatherproofing roof and/or floor penetrations.

In-line Duct-mounted Equipment Bracing Selection

Be sure to refer to construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the in-line duct-mounted equipment

Figure 9: Motorized damper.

Figure 10: Motorized damper.

Figure 11: Combination smoke and fire damper.

Figure 12: Square duct-mounted fire damper.

Figure 13: Round fire damper.

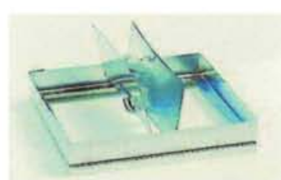


Figure 14: Ceiling fire damper.

Figure 15: Coil.

Figure 16: Humidifier.

Figure 17: Silencer.

Figure 18: Fan-coil unit.

Figure 19: VAV terminal unit.

Figure 20: In-line fan.

Step 2: Select the attachment type

Using the following table, select the attachment that best matches the installation you have selected, then turn to the page listed under the attachment type.

Typical Arrangements	*How is equipment to be installed?*	*Attachment Type*
Coil, damper, in-line fan, fan-coil unit, duct silencer, or VAV terminal unit	Suspended from the structure above using rods and cables	Rigid *Go to page 85*
	Suspended from the structure above using isolators, rods and cables	Isolated *Go to page 90*
	Suspended from the structure above using angles	Rigid with angles *Go to page 88*
Humidifier	Supported by the duct wall	Follow manufacturer's instructions
	Suspended from the structure	

Table 2: In-line duct-mounted equipment installation types.

Pipe Bracing Selection

Be sure to refer to approved construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the pipe bracing used

Figure 21 shows the different ways to brace pipes.

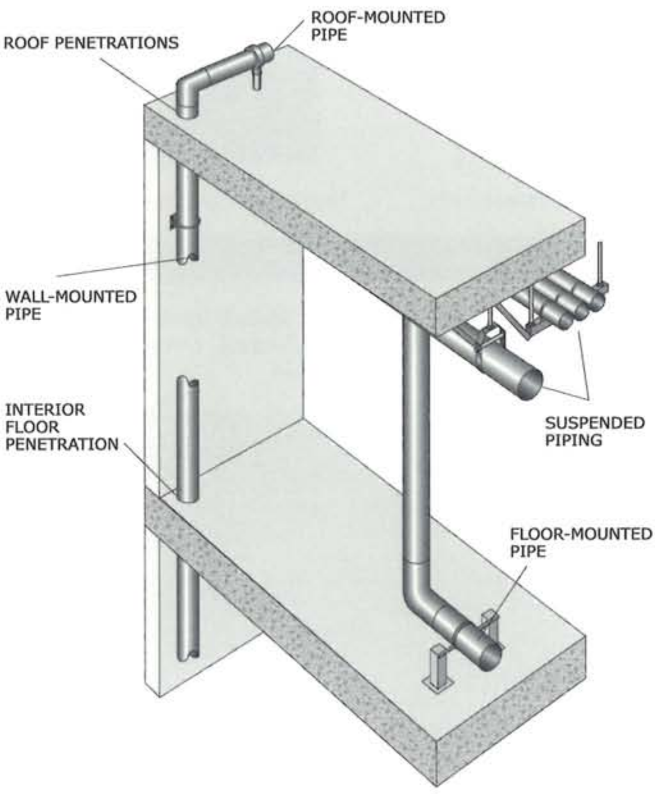


Figure 21: Pipe system with different seismic bracing.

In-line pipe-mounted equipment can be found on page 14.

Step 2: Select the bracing type

Using the following table, select the attachment that best matches the installation you have selected, then turn to the page listed under the bracing type.

Typical Arrangements	*How is equipment to be installed?*	*Bracing Type*
Suspended piping	Suspended with rods and angles using cables or rigid laterals	Suspended piping *Go to page 54*
	Isolated with rod supports and cable bracing	Vibration-isolated *Go to page 65*
Floor-mounted piping	Suspended off the floor with angles/ struts	Floor-mounted piping *Go to page 70*
Roof-mounted piping	Braced above the roof	Roof mounted piping *Go to page 73*
Wall-mounted piping	Supported off the wall	Wall-mounted piping *Go to page 76*
Pipe penetrations	Pipes through building structure	Pipe penetrations *Go to page 79*
In-line pipe-mounted equipment	Attached to the building structure	In-line pipe - mounted equipment *Go to page 14*

Table 3: Pipe bracing installation types.

Refer to approved contract documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers and seismic separation joints.

Refer to approved contract documents for requirements for weatherproofing roof and/or floor penetrations.

Spacing requirements for rigid angle bracing may be less than spacing of cable bracing due to the additional weight of the bracing.

In-line Pipe-mounted Equipment Bracing Selection

Be sure to refer to approved construction drawings and specifications, seismic restraint submittals, and manufacturer's instructions.

Step 1: Identify the in-line pipe-mounted equipment

Figure 22: Valves and valve air actuator.

Figure 23: Valve and electronic actuator.

Figure 24: In-line pump.

Figure 25: Air separator.

Figure 26: Heat exchanger.

Figure 27: Strainer.

Step 2: Select the attachment type

Using the following table, select the attachment that best matches the installation you have selected, then turn to the page listed under the attachment type.

Typical Arrangements	*How is equipment to be installed?*	*Attachment Type*
Valve or strainer	Requires additional bracing at the valve and actuator if it weighs more than 20 pounds	Valves and valve actuators *Go to page 144*
Valve actuator	Requires additional bracing if it weighs more than 20 pounds	
Air separator, in-line pump or heat exchanger	Support piping near equipment/valve	Suspended piping and pumps *Go to page 97* Air separator *Go to page 99* Heat exchanger *Go to page 100*

Table 4: In-line pipe-mounted equipment installation types.

Valves with brittle valve bodies/connections require bracing near the valve.

Strainers and other piping specialties are braced similar to valves.

DUCT BRACING DETAILS AND INSTALLATION INSTRUCTIONS

This section gives instructions on bracing six different kinds of ducts:

- Suspended rectangular ducts (this page).
- Suspended round ducts (page 28).
- Floor-mounted ducts (page 41).
- Roof-mounted ducts (page 44).
- Wall- and chase-mounted ducts (page 47).
- Duct penetrations (page 50).

Suspended Rectangular Ducts

The six ways to brace suspended rectangular ducts are by using:

- Vertical rods with cable bracing (page 17).
- Vertical rods with steel-shaped bracing (page 20).
- Vertical steel shapes with cable bracing (page 22).
- Vertical steel shapes with steel-shaped bracing (page 23).
- Unbraced supports (page 24).
- Vibration-isolated rectangular duct (page 26).

For post-tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers, and seismic separation joints.

Pre-approved manufacturer's/industry manuals used for the installation of duct and pipe bracing are required to be on the job site to ensure that the correct details are being used.

Bracing must not be attaced to duct joint.

Vertical rods with cable bracing

Vertical rod-braced ducts with transverse and longitudinal supports are shown in Figure 28 (below), Figure 29 (page 18), and Figure 30 (page 19).

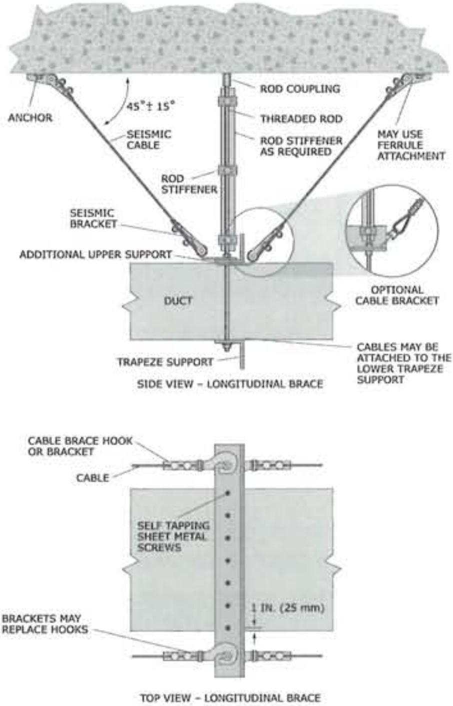


Figure 28: Rectangular duct with vertical rods and braced with cables (longitudinal).

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Do not use coupling nuts except at building structure connection.

Longitudinal cable bracing requires bracing in both directions (as shown).

Rod must be one piece from building structure to bottom of trapeze support.

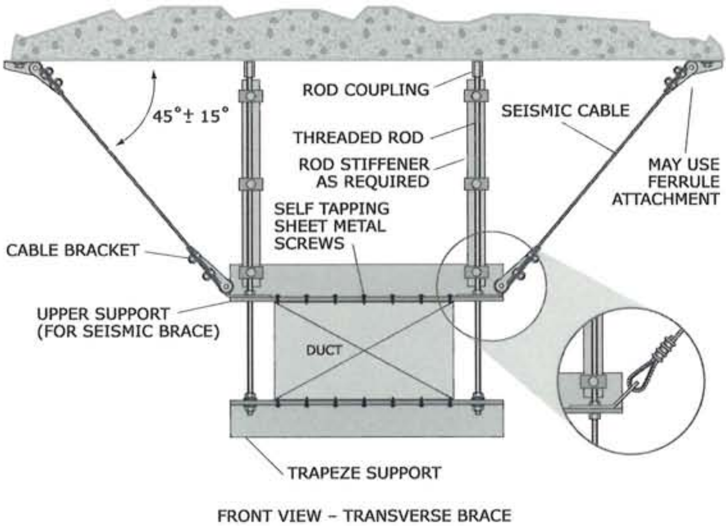


Figure 29: Rectangular duct with vertical rods braced with cables (transverse).

Rod must be one piece from building structure to bottom of trapeze support.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

The building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble the support and connect it to vertical rods as shown in Figure 28 (page 17), Figure 29 (above), and Figure 30 (page 19).

Step 3: Install anchors for bracing

Install sheet metal screws to secure duct. Install brackets and cable bracing. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

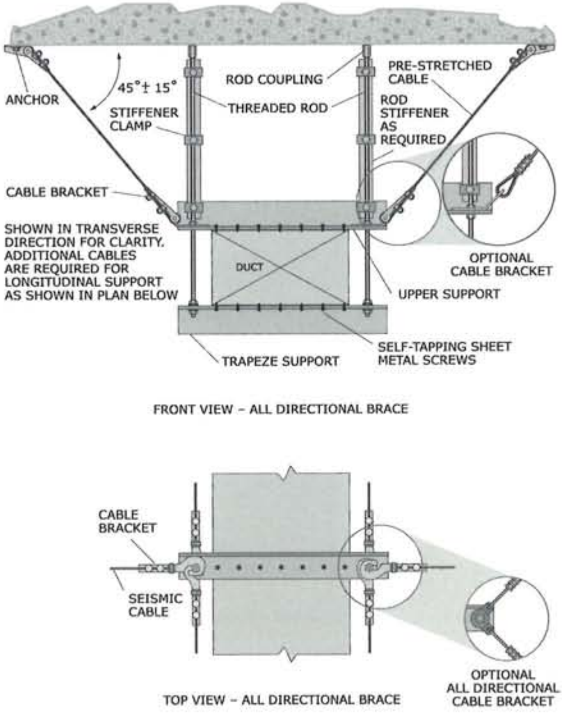


Figure 30: Rectangular duct with vertical rods and braced with cables (all directional).

Rod must be one piece from building structure to bottom of trapeze support.

Do not attach threaded rod and cable to the same anchor.

END OF DETAIL.

Vertical rods with steel shaped bracing

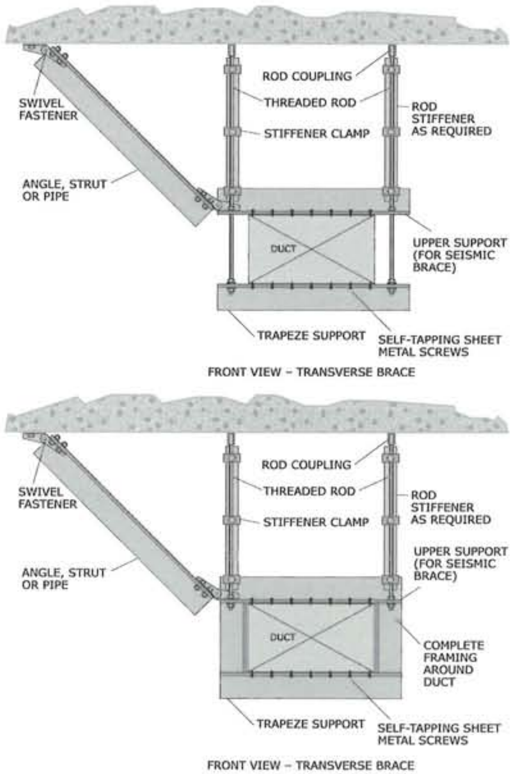


Figure 31: Rectangular duct with vertical rods and braced with steel shapes (transverse).

Rod must be one piece from building structure to bottom of trapeze support.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Additonal weight of steel shaped bracing added to dead load and seismic lateral load may reduce brace spacing or increase rod and rod anchor sizes.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble the support and connect to vertical rods as shown in the Figure 31 (page 20).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Vertical steel shapes with cable bracing

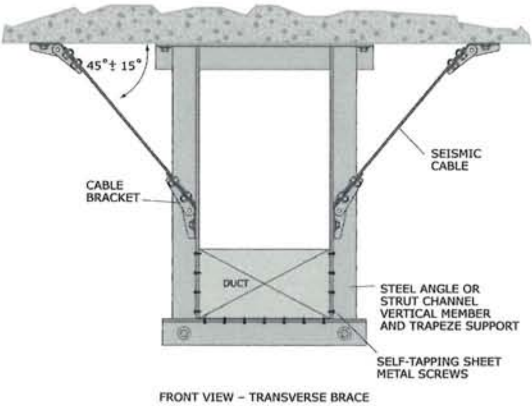


Figure 32: Rectangular duct with steel shapes and braced with cables (transverse).

Step 1: Attach vertical steel shapes to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble the support and connect to vertical rods as shown in the Figure 32 (above).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Vertical steel shapes with steel shaped bracing

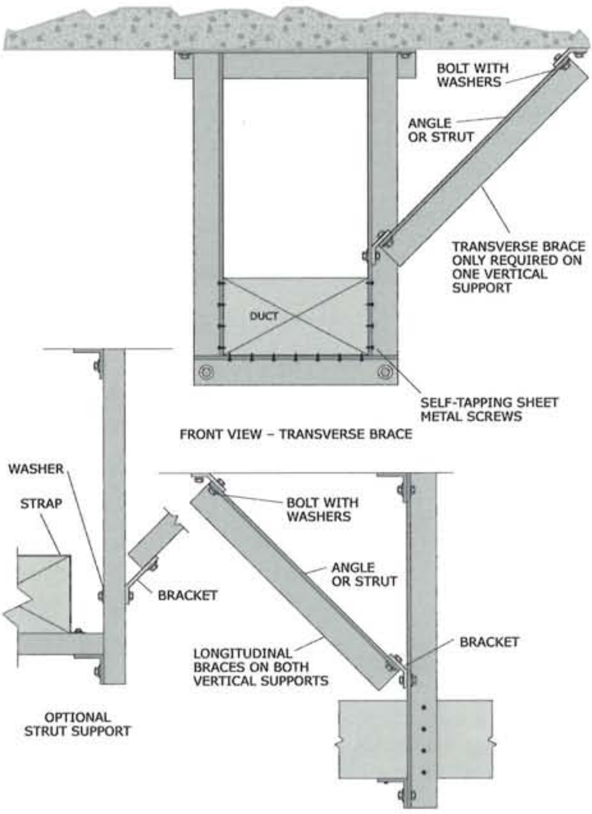


Figure 33: Rectangular duct with vertical steel shapes and steel shaped bracing (transverse and longitudinal).

Rod must be one piece from building structure to bottom of trapeze support.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Step 1: Attach vertical rods to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble duct bracing and connect to vertical angles as shown in the Figure 33 (page 23).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Unbraced supports

Unbraced supports may be allowed by the authority having jurisdiction and may require the top of the duct to be attached to the support.

Refer to building codes for required exceptions to unbraced piping and ducts.

There are three types of unbraced supports:

- Non-moment-resistant rod support
- Strap support
- Vibration-isolated support (see the optional view in Figure 34 on page 25)

Non-moment-resistant rod support

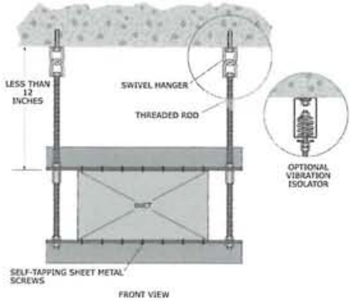


Figure 34: Rectangular duct non-moment-resistant rod support.

Strap support

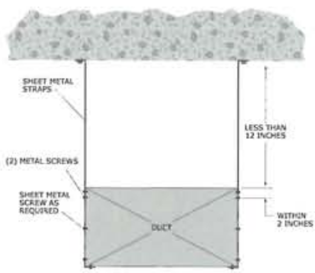


Figure 35: Rectangular duct strap support.

Refer to manufacturer's/industry manuals for size of hanger supports (straps) and spacing.

Step 1: Attach rods/straps to the building structure with anchors

Lay out all attachment points before anchoring. Attach as shown in Figure 34 (above) and Figure 35 (above).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Connect straps to duct as shown in Figure 35 (above) or assemble duct rod support as shown in Figure 36 (page 26).

END OF DETAIL.

Vibration-isolated rectangular duct

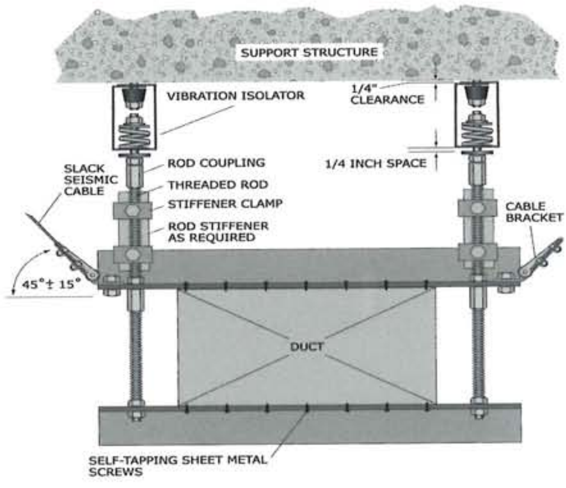


Figure 36: Rectangular duct isolated with vertical rods and braced with cables (transverse).

Verify that the vertical limit stops and clearances meet the manufacturer's requirements.

Step 1: Attach vertical rods with vibration isolators to the building structure

Lay out all the attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For isolator details, refer to Figure 92 (page 91). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble angle bracing and connect to vertical rods as shown in Figure 36 (above).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

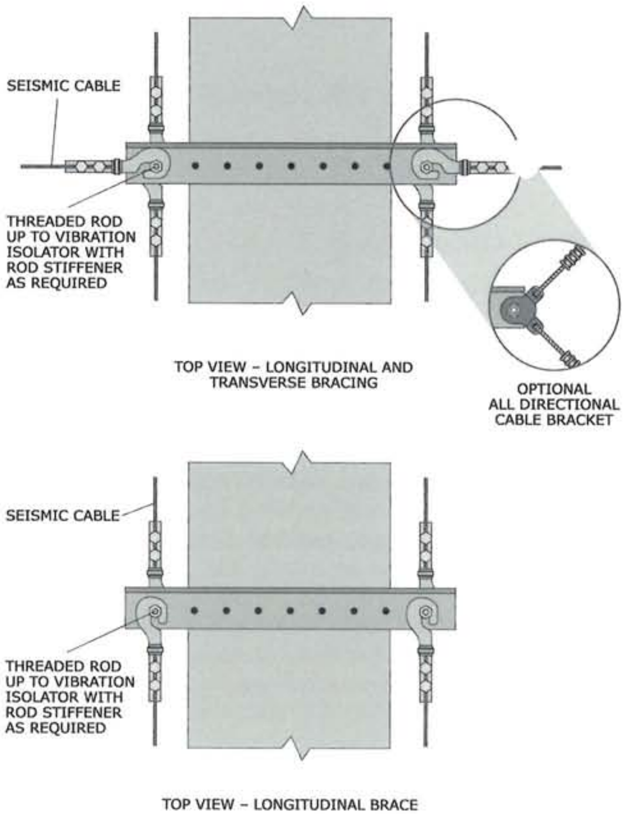


Figure 37: Rectangular duct isolated with rods and braced with cables (all directional and longitudinal).

END OF DETAIL.

Suspended Round Ducts

The six ways to brace suspended round and oval duct supports are by using:

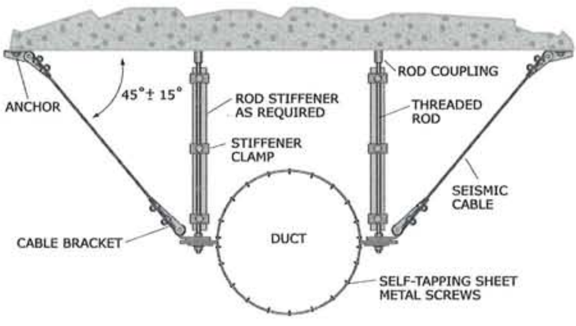
- Vertical rods with cable bracing (page 29).
- Vertical rods with steel shaped bracing (page 32).
- Vertical steel shapes with cable bracing (page 34).
- Vertical steel shapes with steel shaped bracing (page 36).
- Unbraced supports (page 37).
- Vibration isolation (page 39).

For post-tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

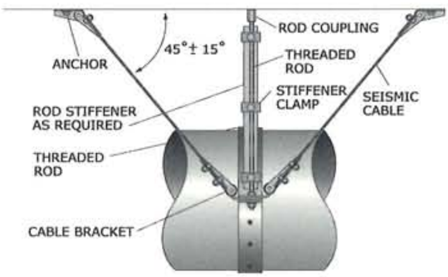
Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers, and seismic separation joints.

Pre-approved manufacturer's/industry manuals used for the installation of duct and pipe bracing are required to be on the job site to ensure the correct details are being used.

Vertical rods with cable bracing



FRONT VIEW - TRANSVERSE BRACE



SIDE VIEW - LONGITUDINAL BRACE

Figure 38: Round duct with vertical rods and braced with cables (transverse and longitudinal).

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Cable bracing requires bracing in both directions as shown in Figure 38 (above).

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

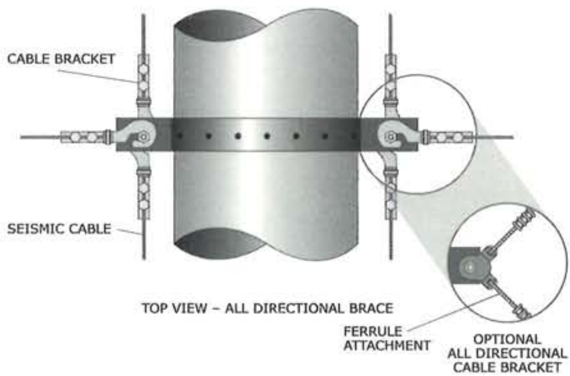


Figure 39: Round duct with vertical rods and braced with cables (all directional).

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Cable bracing requires bracing on both sides as shown in Figure 39 (above) and Figure 40 (page 31).

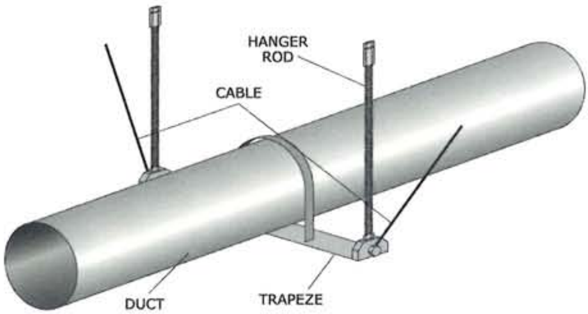


Figure 40: Optional round duct with vertical rods and braced with cables (transverse).

Step 2: Run duct as required by approved construction documents

Assemble the support and connect it to the vertical rods as shown in Figure 39 (page 30) and Figure 40 (above).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Vertical rods with steel shaped bracing

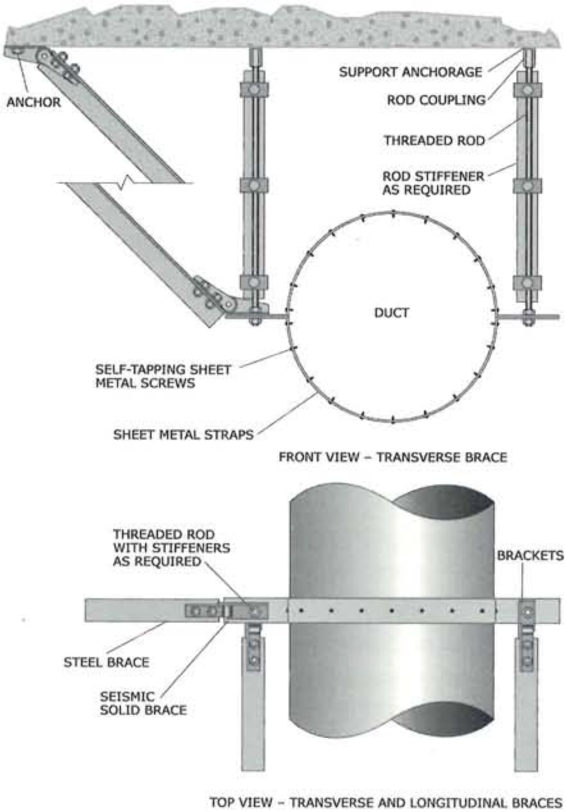


Figure 41: Round duct with vertical rods and braced with steel shapes (transverse and all-directional).

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble angle bracing and connect to vertical rods as shown in Figure 41 (page 32).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Vertical steel shapes with cable bracing

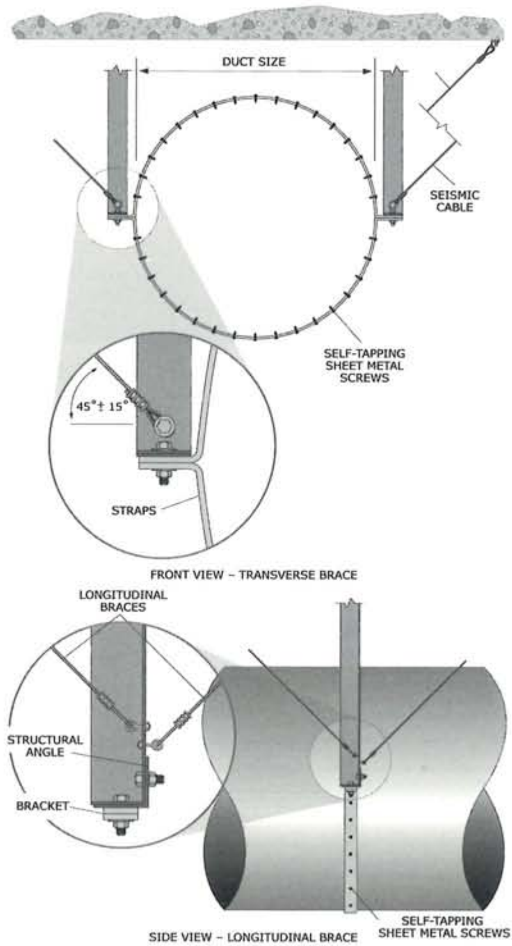


Figure 42: Round duct with vertical steel shapes and braced with cables (transverse and longitudinal).

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Cable bracing requires bracing on both sides as shown in Figure 42 (above).

Step 1: Attach vertical steel shapes with hanger to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble the support and connect it to vertical steel shapes as shown in Figure 42 (page 34).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Vertical steel shapes with steel shaped bracing

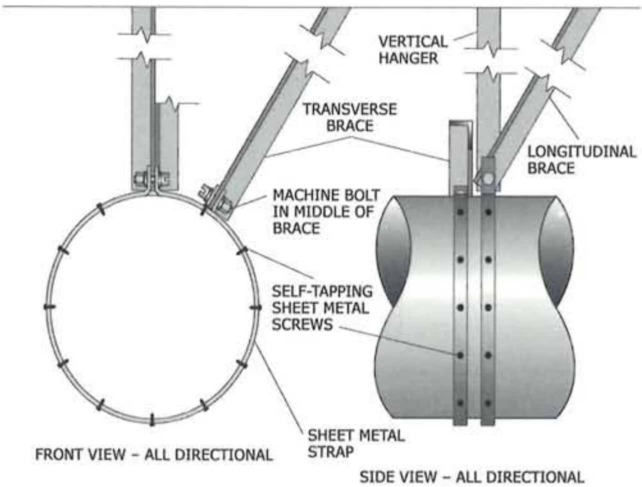


Figure 43: Round duct with vertical steel shapes with steel shaped bracing (all-directional).

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Step 1: Attach vertical steel shapes to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble duct bracing and connect to vertical angles as shown in Figure 43 (above).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Unbraced supports

Unbraced supports may be allowed by the authority having jurisdiction and may require the top of the duct to be attached to the support.

Refer to building codes for required exceptions to unbraced piping and ducts.

There are three types of unbraced supports:

- Non-moment-resistant rod support
- Strap support
- Vibration-isolated support (see the optional view in Figure 44 below)

Non-moment-resistant rod support

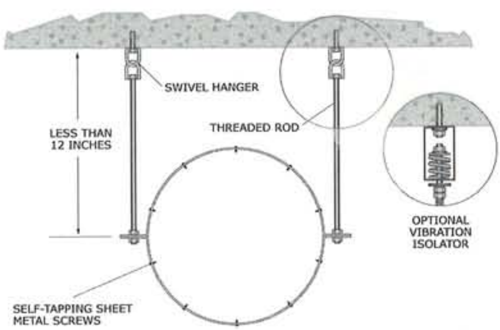


Figure 44: Round duct non-moment-resistant rod support.

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Strap Support

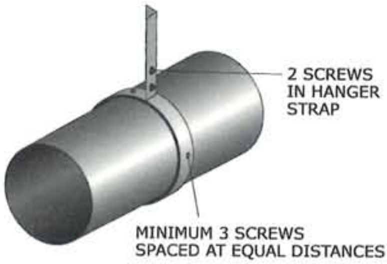


Figure 45: Strap support for round duct with steel shaped bracing.

Refer to manufacturer's/industry manuals for size of hanger supports (straps) and spacing.

Step 1: Attach rods/straps to the building structure with anchors

Lay out all attachment points before anchoring. Attach as shown in Figure 44 (page 37) and Figure 45 (above).

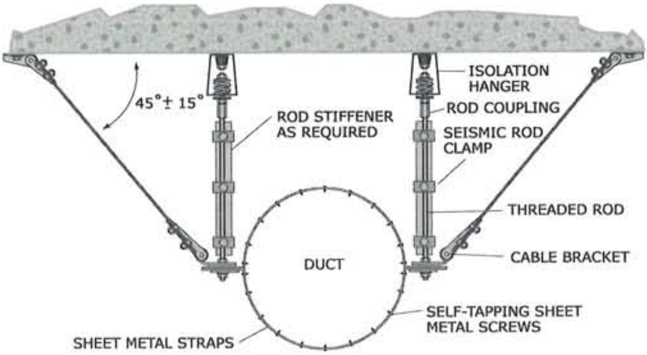
Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

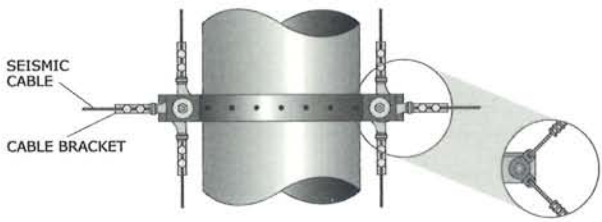
Connect straps to duct as shown in Figure 45 (above) or assemble duct rod support as shown in Figure 46 (page 39).

END OF DETAIL.

Vibration-isolated round duct



FRONT VIEW - TRANSVERSE BRACING



TOP VIEW - ALL DIRECTIONAL BRACING

Figure 46: Round duct isolated with vertical rods and braced with cables (all-directional and transverse).

Verify that the verical limit stops and clearances meet the manufacturer's requirements.

Step 1: Attach vertical rods with vibration isolators to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point load capable. Verify with the appropriate design professional.

Step 2: Run duct as required by approved construction documents

Assemble angle bracing and connect to vertical rods as shown in Figure 46 (page 39).

Step 3: Install anchors for bracing

Install brackets and cable bracing to building structure and support. For cable assembly instructions, see Cables (page 134). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Floor-mounted Ducts

Ducts are usually raised off the floor with a steel shaped support system. Figure 47 (page 42) and Figure 48 (page 43) show the support with structural steel shapes.

For post-tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers, and seismic separation joints.

Step 1: Lay out the duct run

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102).

Step 2: Install anchors for bracing

For instructions on installing anchors, see Anchors (page 107).

Step 3: Assemble angles or straps and secure to anchors and duct with sheet metal screws

Step 4: Run duct as required by approved construction documents

Attach duct to angle assembly with angles and sheet metal screws. For round ducts, attach duct to assembly with straps and sheet metal screws.

Bracing Details and Installation Instructions: Floor-mounted Ducts

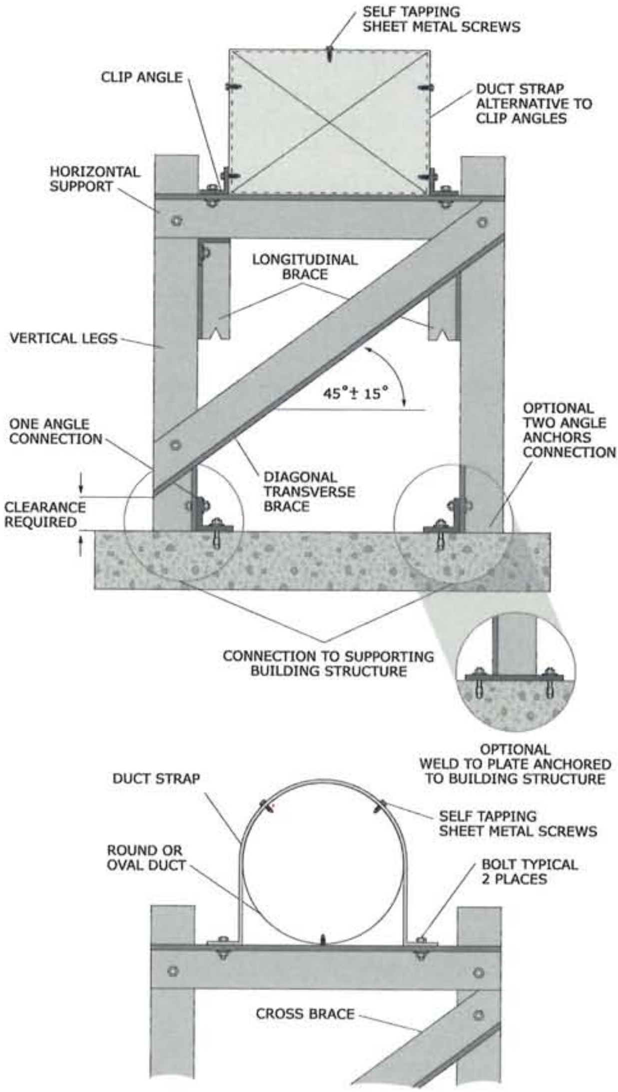
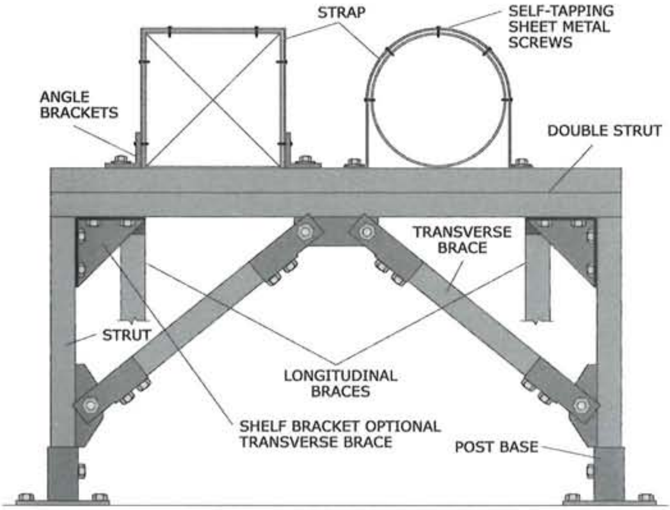


Figure 47: Duct supported off the floor with angles.

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.



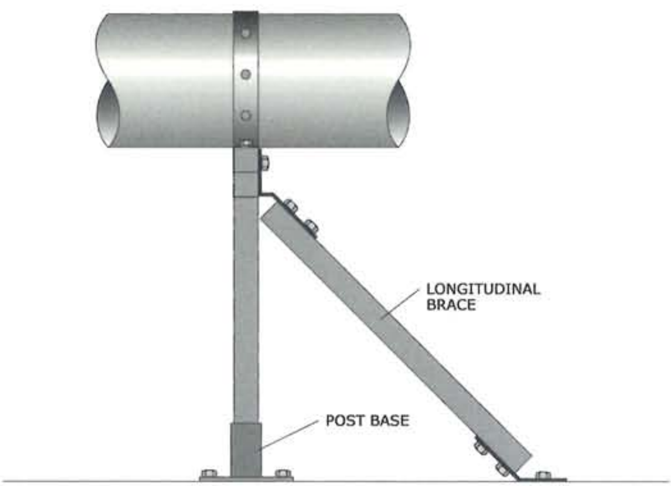


Figure 48: Duct supported off the floor with struts.

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Roof-mounted Ducts

Ducts are usually supported above the roof with angles.

For post-tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers, and seismic separation joints.

The four ways to install roof-mounted ducts are:

- Mounted to a pre-manufactured seismic duct brace (Figure 49, below).
- Mounted to an angle support with cross bracing attached to a roof curb (Figure 50, page 45).
- Mounted to an angle support attached directly to the roof in a pitch pocket to seal the roof (Figure 51, page 45).
- Mounted to an angle support for round or oval ducts (Figure 52, page 46).

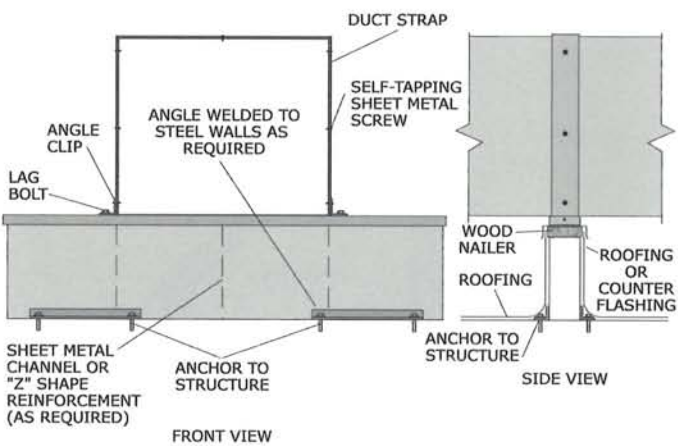


Figure 49: Duct mounted to a pre-manufactured seismic duct brace.

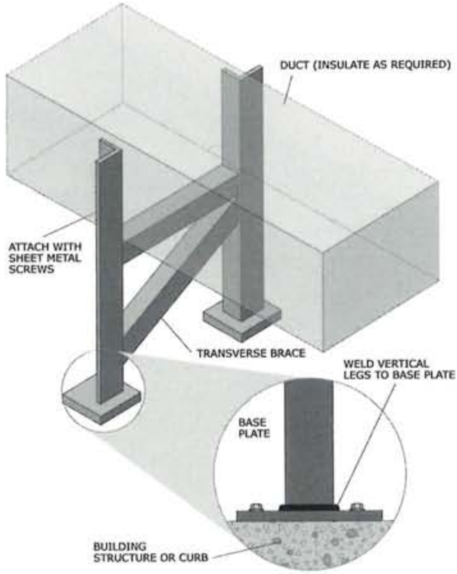


Figure 50: Duct mounted to the roof with cross bracing on a curb.

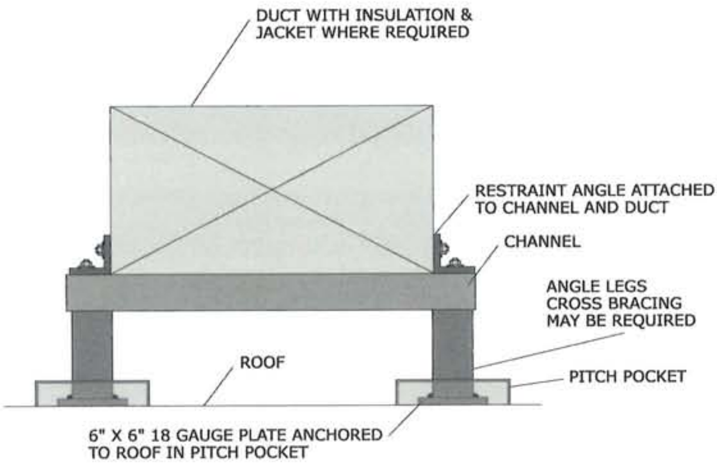


Figure 51: Duct mounted and directly attached to the roof in a pitch pocket.

Insulate duct with weatherproof jacket where required.

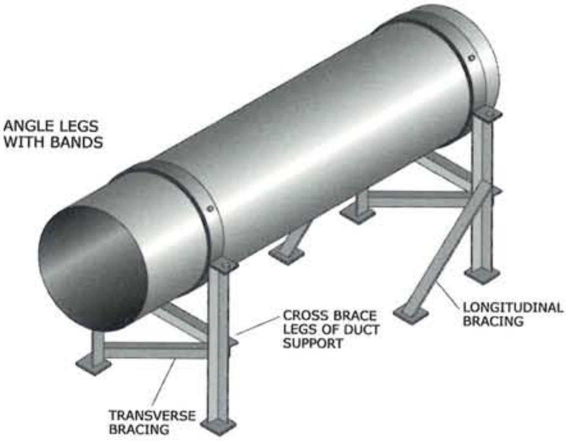


Figure 52: Round duct roof support.

Step 1: Lay out the duct run

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 2: Assemble support

Step 3: Anchor support base plate to building structure

Step 4: Run duct as required by approved construction documents

Attach duct to the angle assembly with angles and sheet metal screws. For round ducts, attach duct to the assembly with straps and sheet metal screws and bolts as required.

Seal all anchors and sheet metal screws and make weatherproof.

END OF DETAIL.

Wall- and Chase-mounted Ducts

Ducts are usually directly attached to the wall with straps or angles. Ducts can also be supported in a chase.

For post-tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers, and seismic separation joints.

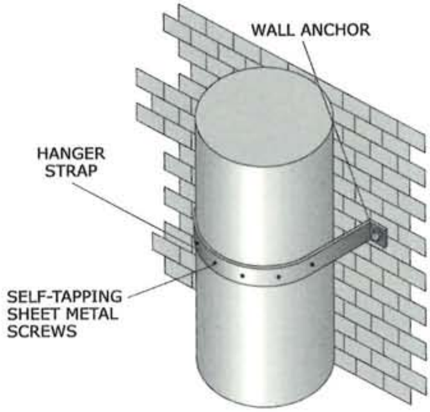


Figure 53: Strap connected directly to wall.

Straps in Figure 53 (above) do not provide vertical bracing.

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

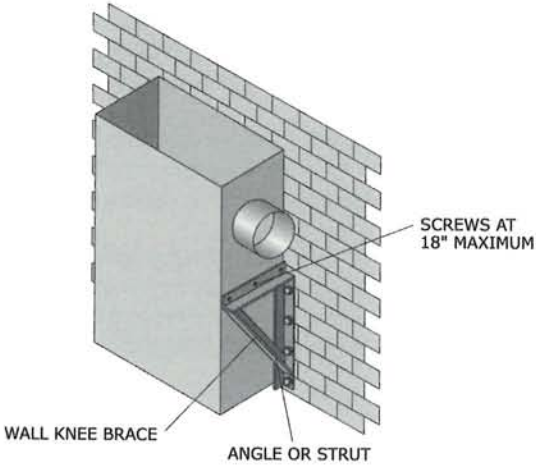


Figure 54: Duct supported by angles.

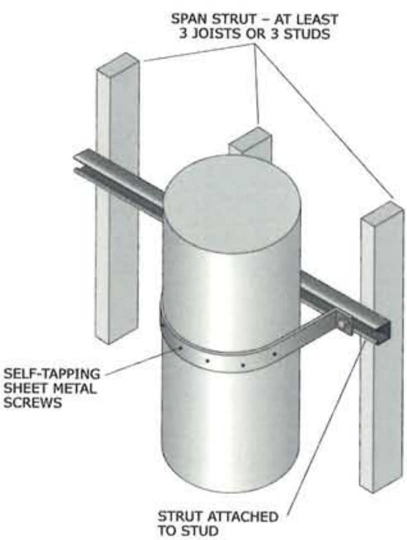


Figure 55: Duct supported from wood or metal stud wall.

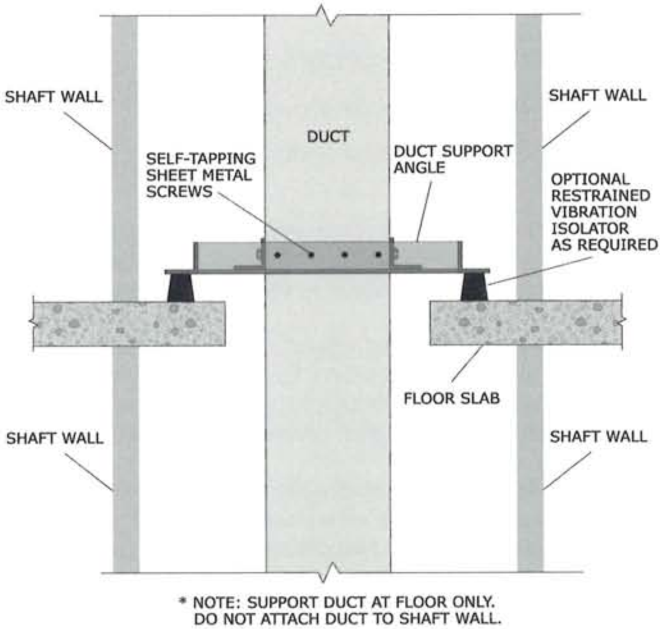


Figure 56: Duct supported in chase.

Step 1: Lay out the duct run

Lay out all the attachment points before anchoring.

Step 2: Run duct as required by approved construction documents

Step 3: Install anchors for bracing

For instructions on installing anchors, see Anchors (page 107).

Step 4: Assemble angles or straps and secure to anchors and duct with sheet metal screws

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

END OF DETAIL.

Duct Penetrations

The two types of duct penetrations are:

- Roof duct penetrations (this page).
- Interior duct penetrations (page 52).

For post-tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers, and seismic separation joints.

Pre-approved manufacturer's/industry manuals used for the installation of duct and pipe bracing are required to be on the job site to ensure the correct details are being used.

All roof penetrations should be sealed and may require flashing.

Roof duct penetrations

Coordinate roof penetrations with the roofing contractor.

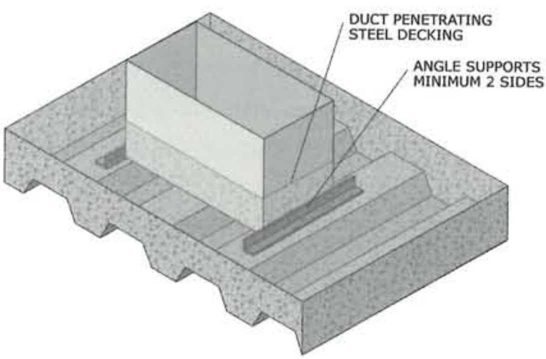


Figure 57: Duct penetration through metal deck roof.

Step 1: Lay out the location of penetration

Coordinate the layout with a structural engineer. Additional structural supports may be required.

Lay out all attachment points before anchoring.

Step 2: Install anchors for bracing

For instructions on installing anchors, see Anchors (page 107).

Step 3: Run duct as required by approved construction documents

Attach duct to the angle assembly with angles and sheet metal screws. For round ducts, attach duct to the assembly with split band and sheet metal screws and bolts as required. Attach angles to the building structure.

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Step 4: Add flashing

Add flashing as required by approved contract documents or as directed in manufacturer's instructions. See Figure 58 (below).

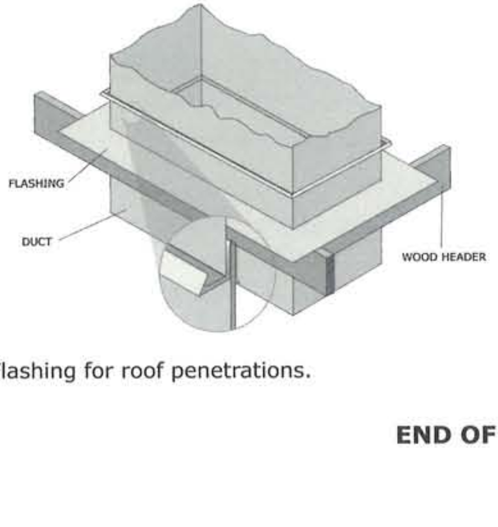
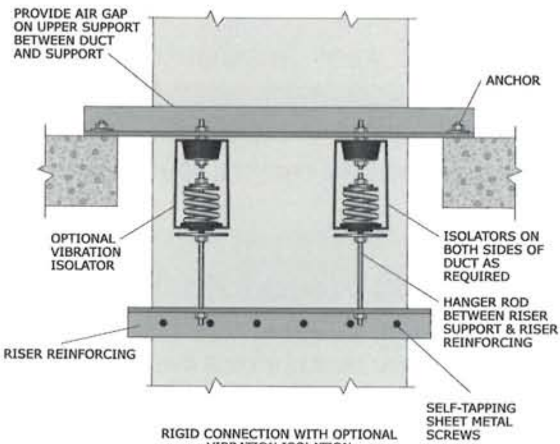


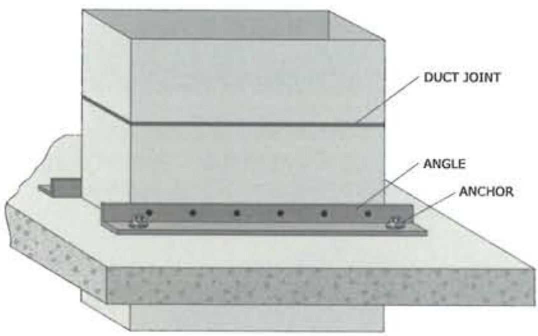
Figure 58: Flashing for roof penetrations.

END OF DETAIL.

Interior duct penetrations



RIGID CONNECTION WITH OPTIONAL VIBRATION ISOLATION



RIGID CONNECTION

Figure 59: Penetration for interior rectangular duct.

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

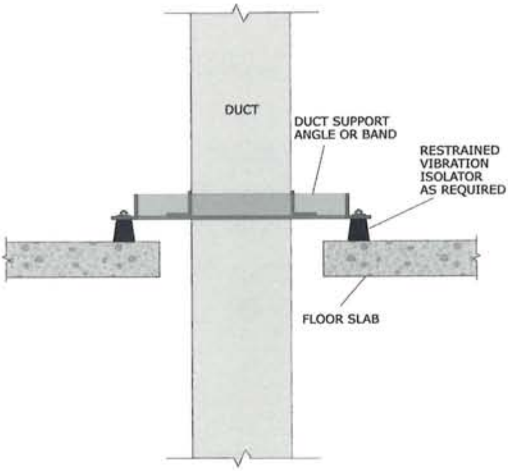


Figure 60: Penetration for interior round duct.

Step 1: Lay out the location of penetration

Coordinate the layout with a structural engineer. Additional structural supports may be required.

Lay out all attachment points before anchoring.

Step 2: Install anchors for bracing

For instructions on installing anchors, see Anchors (page 107).

Step 3: Run duct as required by approved construction documents

Attach duct to the angle assembly with angles and sheet metal screws. Attach angles to the building structure.

Use the shortest screws possible when penetrating ductwork to minimize airflow noise inside the duct.

Duct penetrations may be similar to pipe penetrations (page 79).

END OF DETAIL.

PIPE BRACING DETAILS AND INSTALLATION INSTRUCTIONS

This section gives instructions on bracing five different kinds of piping:

- Suspended piping (this page).
- Floor-mounted piping (page 70).
- Roof-mounted piping (page 73).
- Wall-mounted piping (page 76).
- Pipe penetrations (page 79).

Suspended Piping

The seven ways to brace suspended piping are by using:

- Clevis hanger braced at the restraining bolt (page 55).
- Clevis hanger braced with cables (page 57).
- Clevis hanger braced at the hanger rod (page 58).
- Pipe clamps (page 60).
- Isolated pipe with clevis hanger (page 65).
- Trapeze support system (page 66).
- Double rolier for expansive pipe (page 68).

For post-tension (pre-stressed) buildings, locate the tendons before drilling. Extreme damage may occur if a tendon is nicked or cut.

Refer to approved construction documents for details and provisions for crossing fire barriers, area separation walls/floors/roofs, smoke barriers, and seismic separation joints.

Pre-approved manufacturer's/industry manuals used for the installation of duct and pipe bracing are required to be on the job site to ensure that the correct details are being used.

Suspended using clevis hanger braced at the restraining bolt

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run pipe as required by approved construction documents

Step 3: Install anchors for bracing

For instructions on installing anchors, see Anchors (page 107).

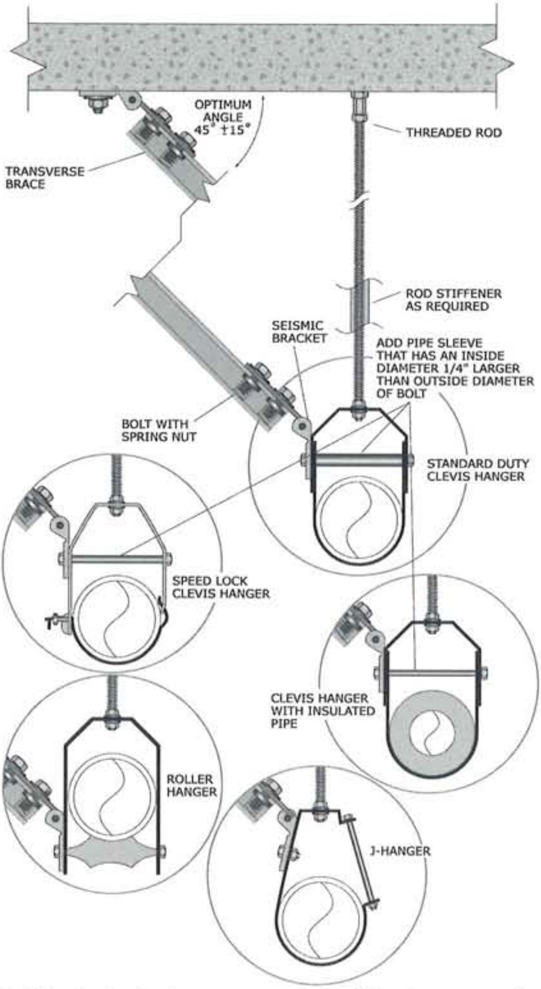


Figure 61: Single clevis hanger support with strut or angle transverse bracing at the restraining bolt.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

END OF DETAIL.

Suspended using clevis hanger braced with cables

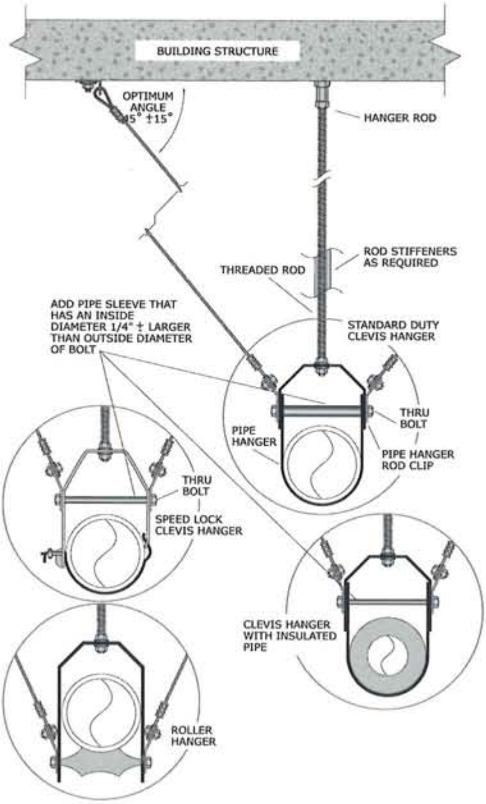


Figure 62: Single clevis hanger support with cable transverse bracing at the restraining bolt.

For cable assembly instructions, see Cables (page 134). For details on attaching cable to the building structure, refer to Attachment Details Connecting to Building Structure (page 102). For angle and strut attachment, see Figure 61 (page 56).

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

END OF DETAIL.

Suspended using clevis hanger braced at the hanger rod

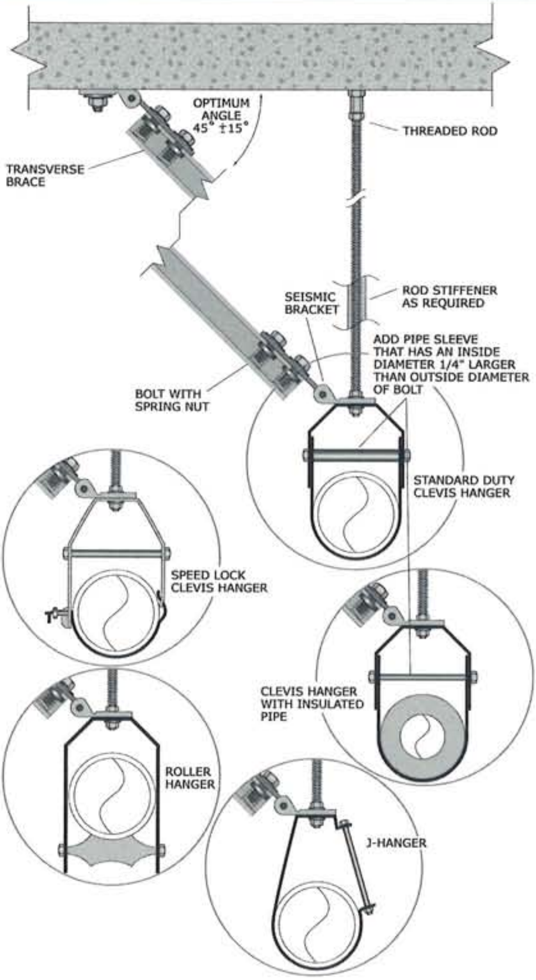


Figure 63: Single clevis hanger support with strut or angle transverse bracing at hanger rod.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

Step 1: Attach vertical rods with hangers to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run pipe as required by approved construction documents

Step 3: Install anchors for bracing

For cable assembly instructions, see Cables (page 134). For details on attaching cable to the building structure, see Attachment Details Connecting to Building Structure (page 102). For angle and strut attachment, see Figure 63 (page 58). For instructions on installing anchors, see Anchors (page 107).

Insulate pipe with weatherproof jacket where required.

END OF DETAIL.

Suspended using pipe clamps

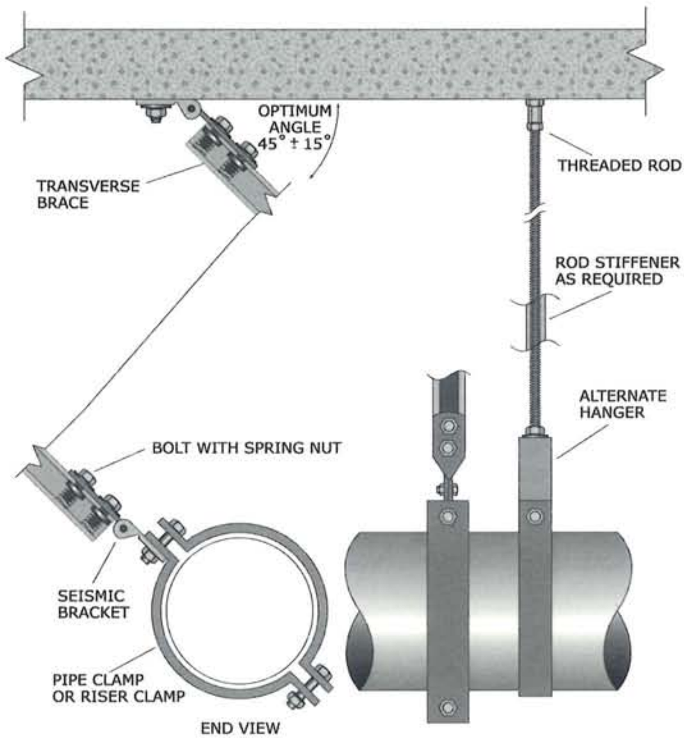


Figure 64: Pipe clamp supports with transverse strut or angle, transverse brace and hanger rod.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

Insulate after attaching pipe clamp.

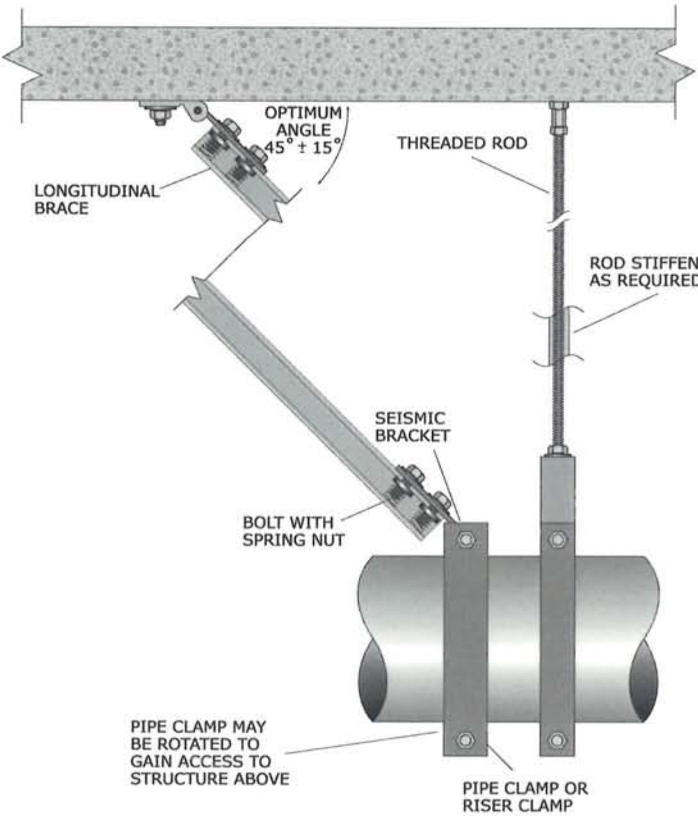


Figure 65: Pipe clamp supports with longitudinal strut or angle, longitudinal brace and hanger rod.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Torque bolts per manufacturer's recommendations.

Insulate after attaching pipe clamp.

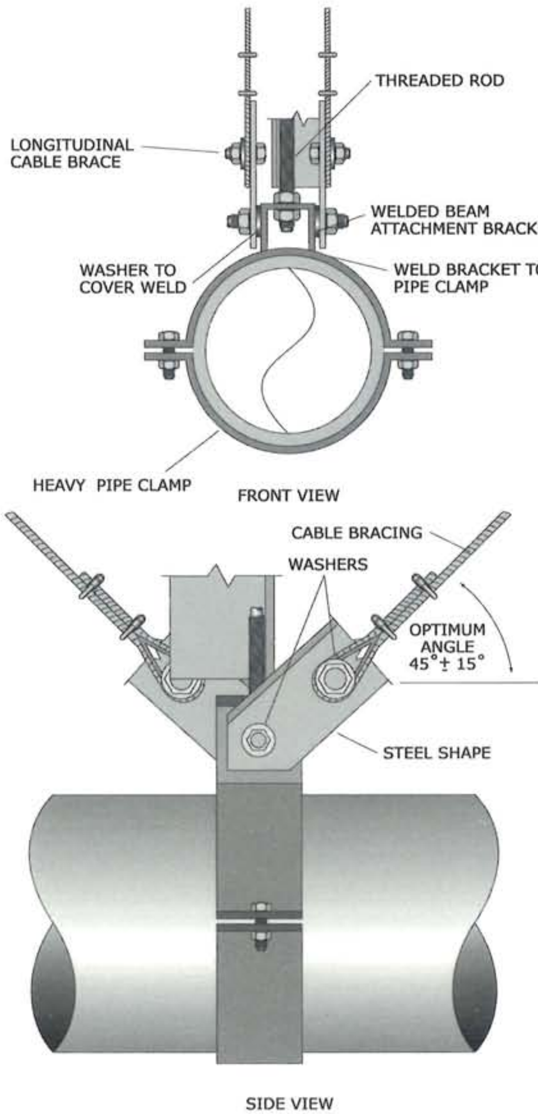


Figure 66: Pipe clamp supports with longitudinal cable brace and hanger rod.

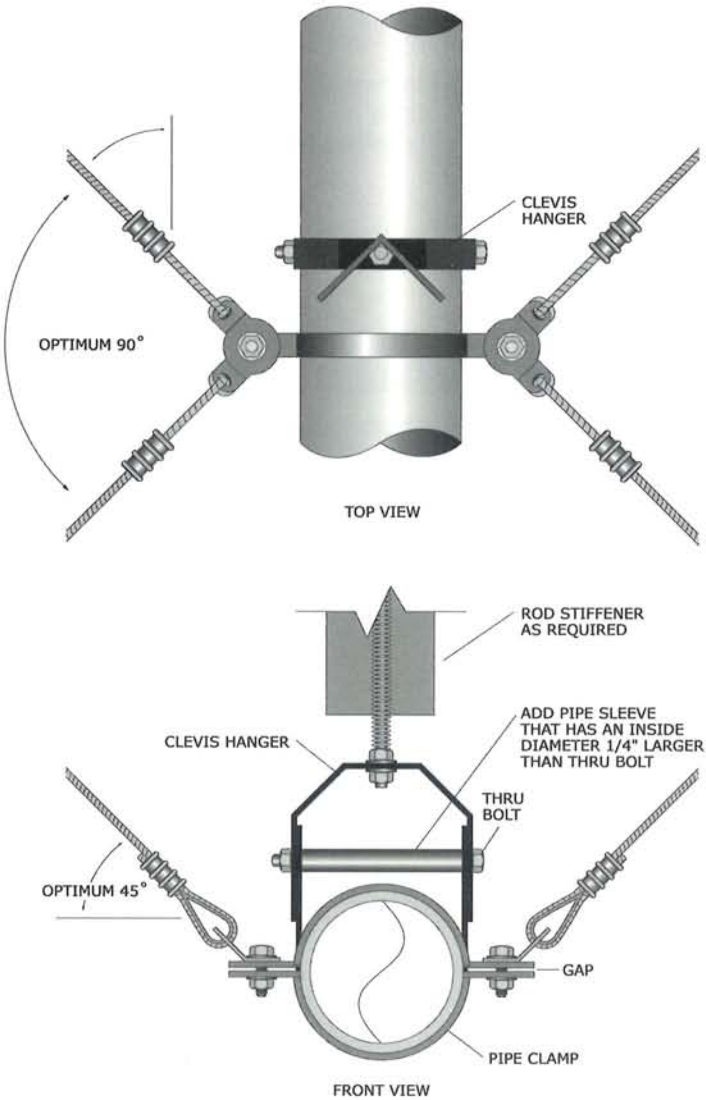


Figure 67: Pipe clamp supports with all directional brace and hanger rod.

Step 1: Attach vertical rods with hanger or vibration isolator (as required) to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point load capable. Verify with the appropriate design professional.

Step 2: Run pipe as required by approved construction documents

Step 3: Install anchors for bracing

For cable assembly instructions, see Cables (page 134). For details on attaching cable to the building structure, refer to Attachment Details Connecting to Building Structure (page 102). For angle and strut attachment, see Figure 69 (page 66). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Vibration-isolated pipe with clevis hanger

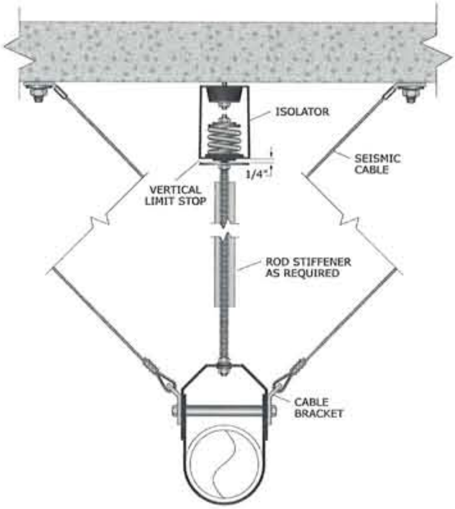


Figure 68: Vibration-isolated single pipe.

Step 1: Attach vertical rods with hanger or vibration isolator (as required) to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point load capable. Verify with the appropriate design professional.

Step 2: Run pipe as required by approved construction documents

Step 3: Install anchors for bracing

For cable assembly instructions, see Cables (page 134). For details on attaching cable to the building structure, refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Suspended with trapeze support system

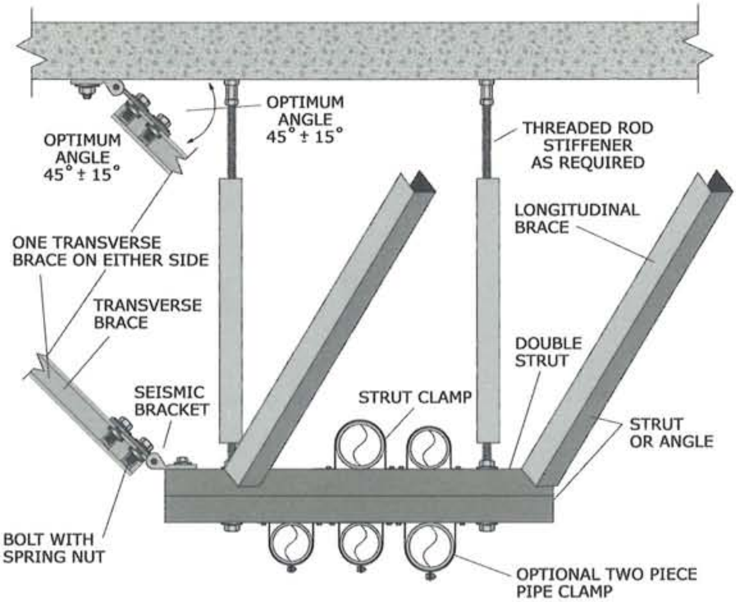


Figure 69: Trapeze support with strut or angle lateral supports.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Separate isolated piping from rigidly braced piping.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point load capable. Verify with the appropriate design professional.

Step 2: Run pipe as required by approved construction documents

Step 3: Install anchors for bracing

For cable assembly instructions, see Cables (page 134). For details on attaching cable to the building structure, refer to Attachment Details Connecting to Building Structure (page 102). For angle and strut attachment, see Figure 69 (page 66). For instructions on installing anchors, see Anchors (page 107).

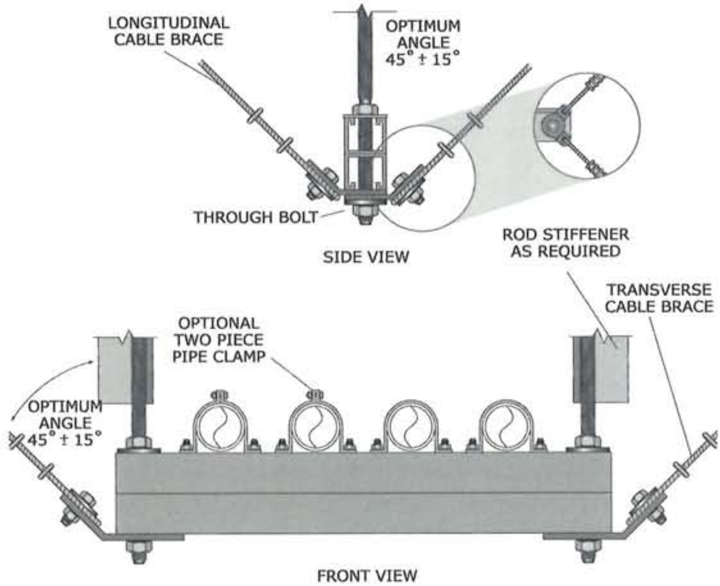


Figure 70: Trapeze support with cable lateral brace.

Separate isolated piping from rigidly braced piping.

END OF DETAIL.

Suspended with double roller support system

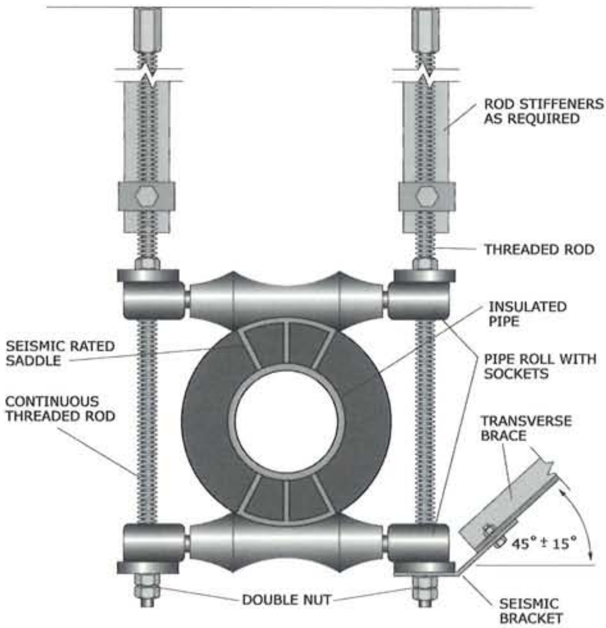


Figure 71: Double roller support for thermally expansive piping.

Pre-approved manufacturer's/industry manuals may limit the maximum transverse and longitudinal angles to 45 degrees.

Step 1: Attach vertical rods with hanger to the building structure

Lay out all the attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Run pipe as required by approved construction documents

Step 3: Install anchors for bracing

For cable assembly instructions, see Cables (page 134). For angle and strut attachment, see Figure 69 (page 66). For instructions on installing anchors, see Anchors (page 107).

END OF DETAIL.

Floor-mounted Piping

Attach to the floor with angles either in a single pipe support configuration as shown in Figure 72 (below) or on a trapeze as shown in Figure 73 (page 71) and Figure 74 (page 72).

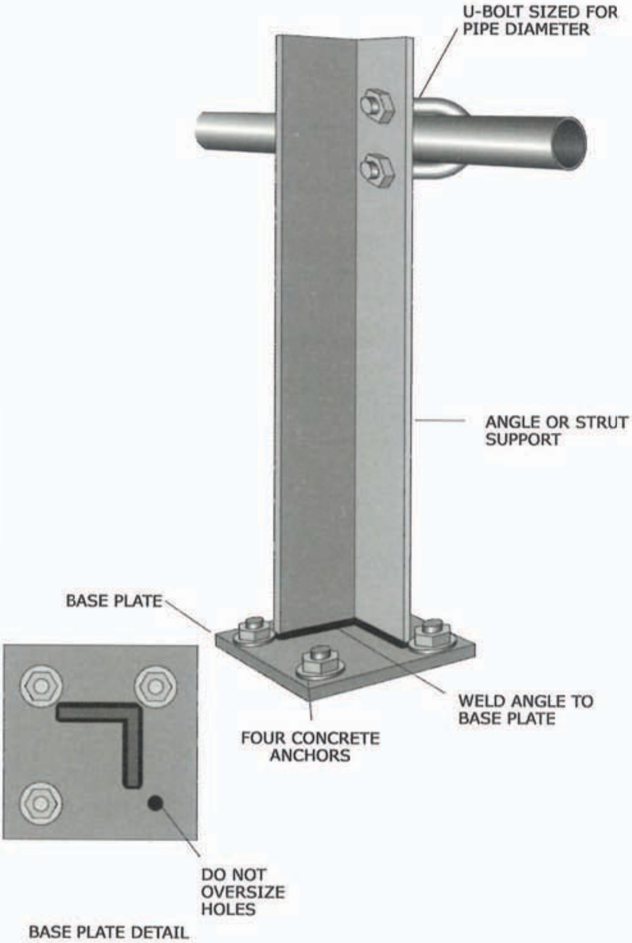


Figure 72: Single vertical support.

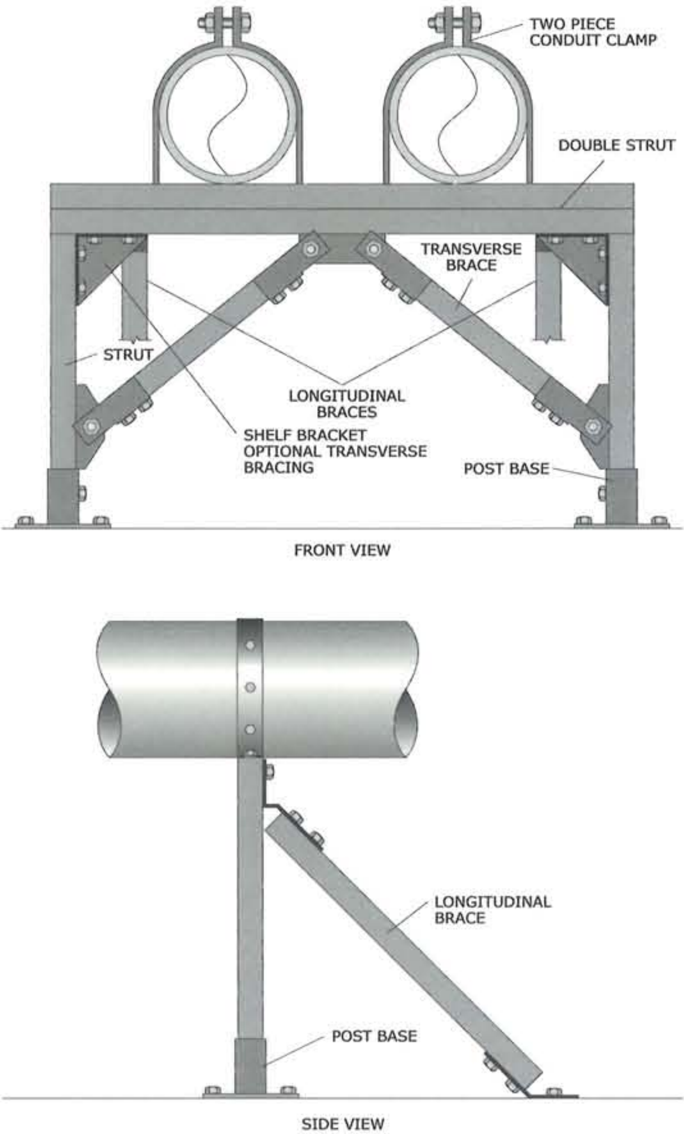


Figure 73: Attachment to a floor with strut trapeze.

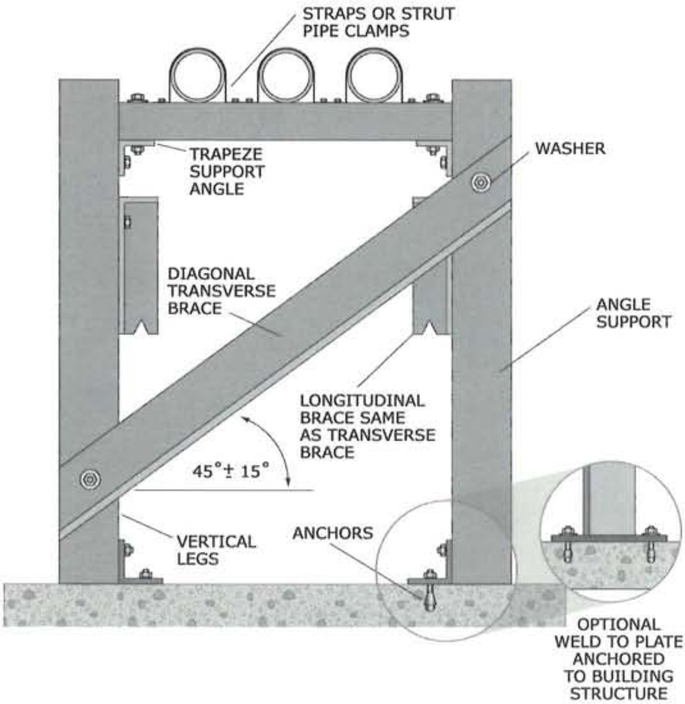


Figure 74: Attachment to a floor with steel shaped trapeze.

Step 1: Attach supports or angles to the floor

For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

Step 2: Build trapeze support and attach piping to support with straps or strut pipe clamps

Torque bolts per manufacturer's recommendations.

END OF DETAIL.

Roof-mounted Piping

The three ways of attaching piping to a roof are:

- Single pipe support (this page).
- Wood blocking support (page 74).
- Trapeze support (page 75).

Single pipe support

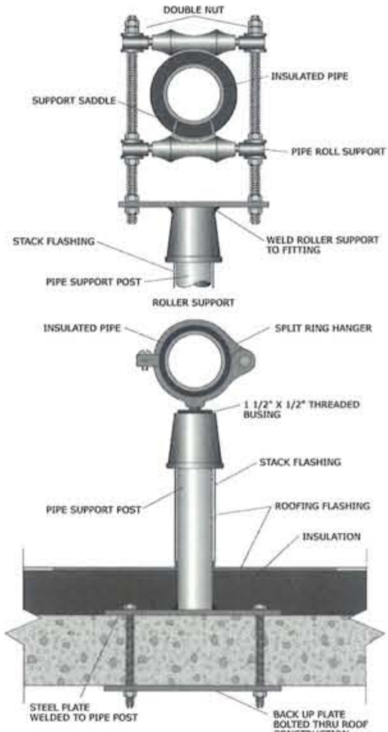


Figure 75: Single pipe support.

Step 1: Attach vertical support to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102).For instructions on installing anchors, see Anchors (page 107).

Step 2: Assemble support and attach to building structure

Apply flashing to roof penetration.

Step 3: Run pipe as required by approved construction documents

END OF DETAIL.

Wood blocking support

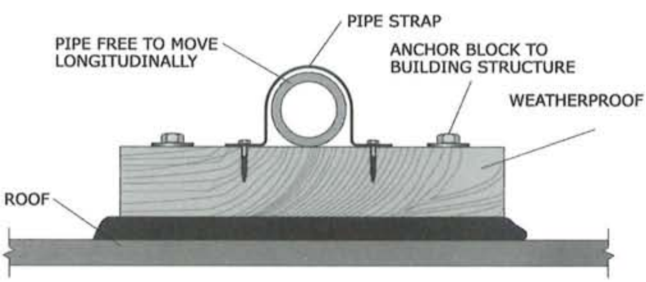


Figure 76: Wood blocking support.

Step 1: Attach wood support to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 2: Apply flashing or sealant to roof penetration

Follow the manufacturer's instructions.

Step 3: Run pipe as required by approved construction documents

END OF DETAIL.

Trapeze support

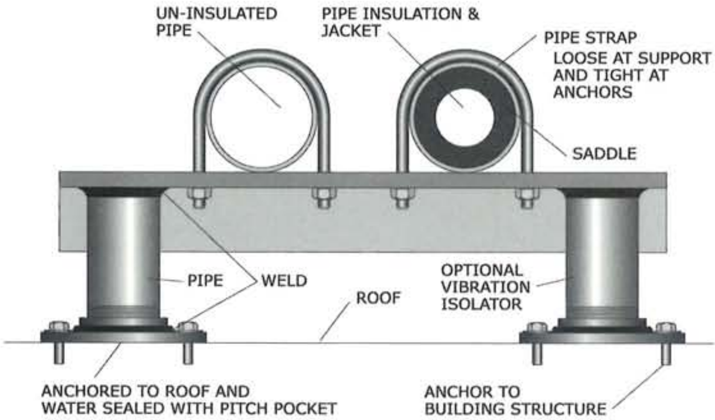


Figure 77: Trapeze support.

Refer to approved contract documents for pitch pocket details.

Separate isolated piping from rigidly braced piping.

Step 1: Lay out the pipe run

Lay out all attachment points before anchoring.

Step 2: Install anchors for bracing

For instructions on installing anchors, see Anchors (page 107).

Step 3: Assemble angles and secure to anchors

Step 4: Run pipe as required by approved construction documents

Attach piping to trapeze support with pipe straps or U-bolts. Provide hard insulation and sheet metal protection shield at the support area.

END OF DETAIL.

Wall-mounted Piping

Directly attach to the wall with two-hole pipe clamps as shown in Figure 78 (below) or with angle brackets as shown in Figure 79 (page 77) and Figure 80 (page 78).

Piping surface-mounted from the underside of a building structural slab or rated structural ceiling should be attached as shown in Figure 78 (below).

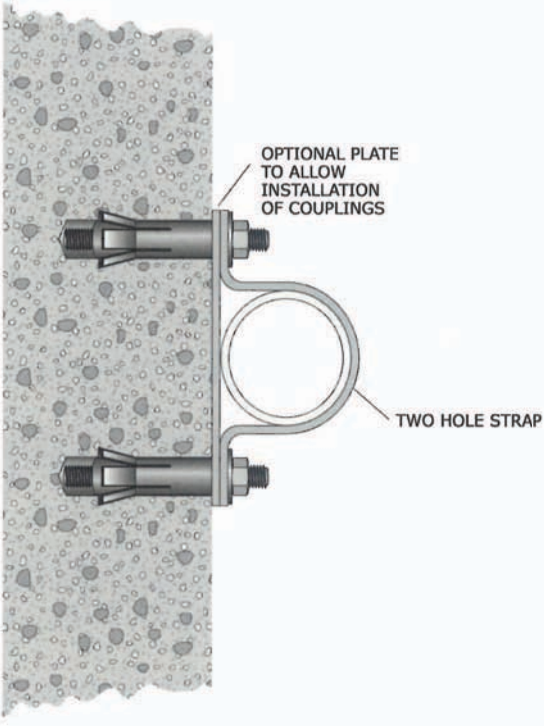


Figure 78: Direct attachment.

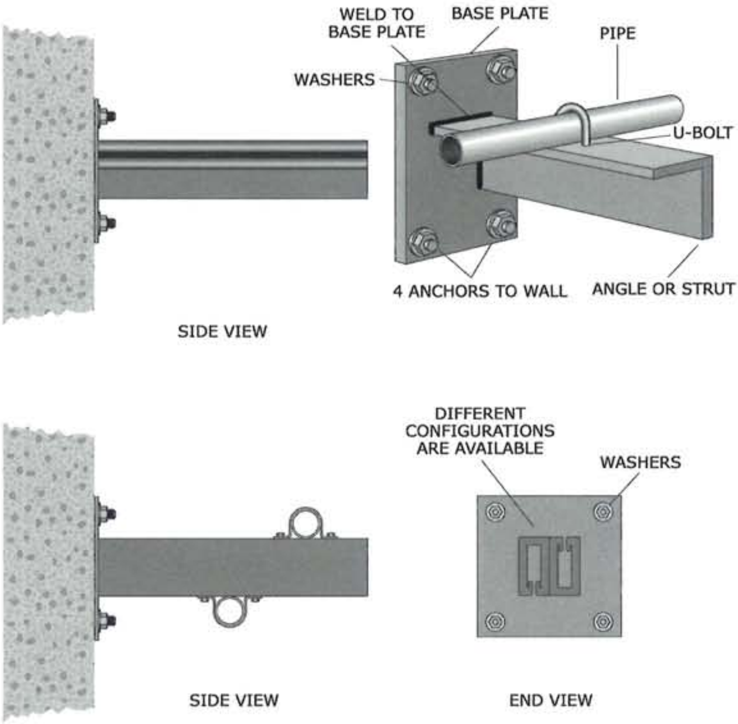


Figure 79: Attachment to the wall with angle or strut welded to attachment plate.

Refer to approved construction documents for limitations to length of standoffs.

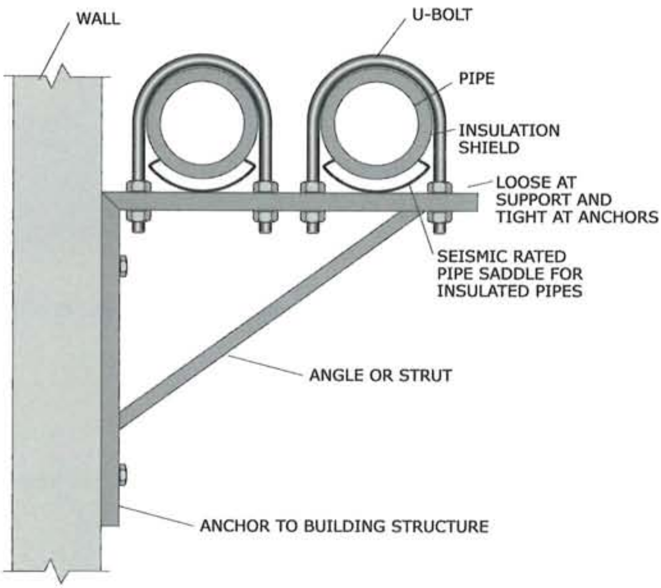


Figure 80: Attachment to studs in the wall with pre-manufactured brackets.

Step 1: If required, attach supports or angles to the wall

For instructions on installing anchors, see Anchors (page 107).

Building structure must be point-load capable. Verify with the appropriate design professional.

For drywall attachments, use a strut attachment to the studs as shown in Figure 55 (page 48).

Step 2: Attach pipe to support with straps

END OF DETAIL.

Pipe Penetrations

The two types of pipe penetrations are:

- Roof pipe penetrations (below).
- Interior pipe penetrations (page 82).

Roof pipe penetrations

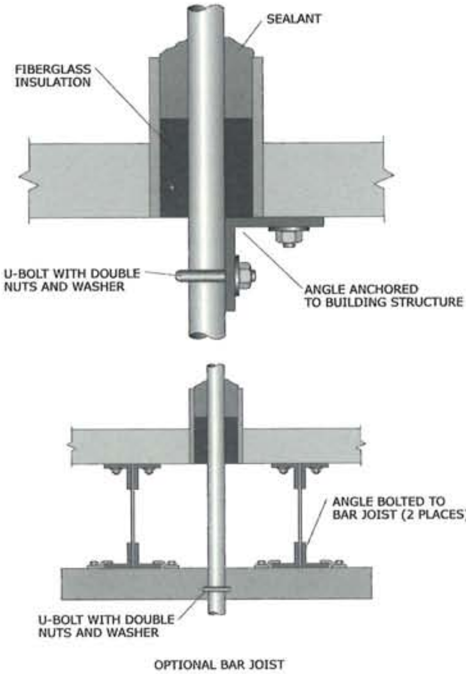


Figure 81: Roof pipe penetration detail.

Refer to Attachment Details Connecting to Building Structure (page 102) for bar joist attachment.

Verify that the bar joist is point load capable.

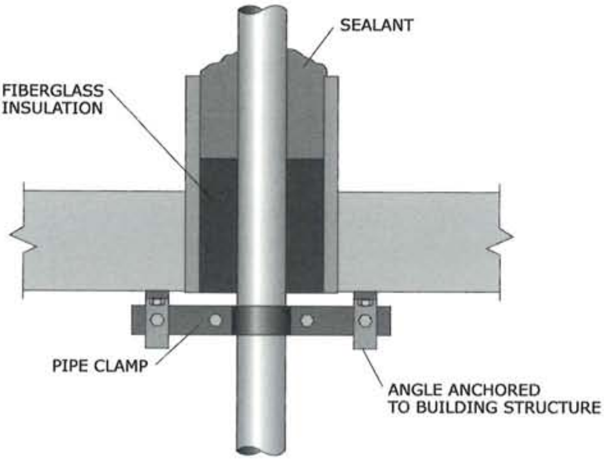


Figure 82: Roof pipe penetration detail.

Step 1: Lay out location of penetration

Coordinate the layout with a structural engineer. Additional structural supports may be required.

Lay out all attachment points before anchoring.

Step 2: Install anchors and attach angles to building structure

For instructions on installing anchors, see Anchors (page 107).

Step 3: Run pipe as required by approved construction documents

Attach pipe to angle assembly with angles and U-bolts or with pipe clamp.

Add flashing as required by approved construction documents or as directed in manufacturer's instructions

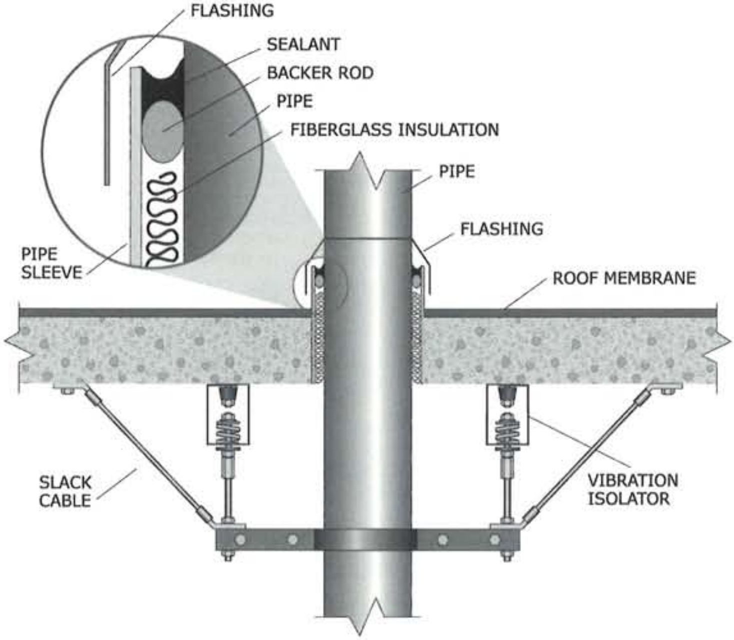


Figure 83: Isolated pipe roof penetration detail.

Separate isolated piping from rigidly braced piping.

END OF DETAIL.

Interior Pipe Penetrations

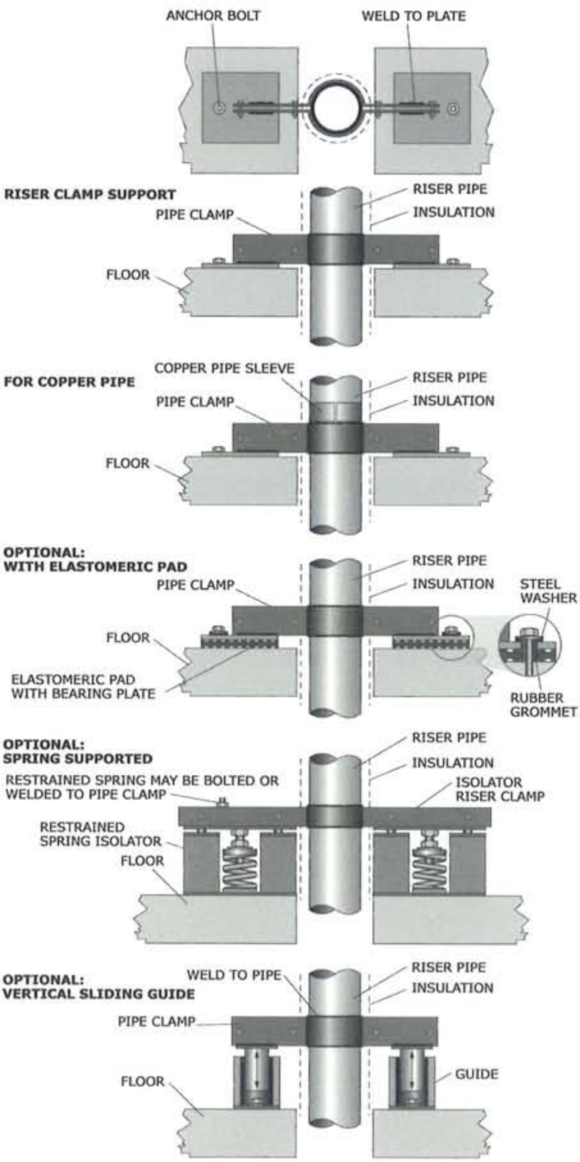


Figure 84: Interior pipe penetration detail.

Step 1: Lay out location of penetration

Coordinate the layout with a structural engineer. Additional structural supports may be required.

Lay out all attachment points before anchoring.

Step 2: Install anchors and attach angles to building structure

For instructions on installing anchors, see Anchors (page 107).

Step 3: Run pipe as required by approved construction documents

Attach pipe to angle assembly with angles and U-bolts or with pipe clamp.

Piping penetrating walls/floor slabs/roofs must be installed per approved construction documents, submittals, or manufacturer's instructions.

Rigid attachment to lightweight walls may cause vibration problems.

Separate isolated piping from rigidly braced piping.

END OF DETAIL.

SUSPENDED EQUIPMENT ATTACHMENT

Do not mix bracing systems for strut and cable bracing.

This section provides instructions for equipment that is:

- Suspended by threaded rods connected to equipment brackets or additional steel supports (this page).
- Suspended by steel shapes (page 95).
- Suspended by threaded rods for in-line pipe equipment (page 97).

Suspended by Threaded Rods Connected to Equipment Brackets or Additional Steel Supports

The four ways to suspend equipment with threaded rods or steel supports are:

- Rigid connection to the building structure using four threaded rods with lateral cable bracing (page 85).
- Rigid connection to the building structure using four threaded rods with lateral steel shaped bracing (page 88).
- Vibration-isolated connection to the building structure using a minimum of four threaded rods and lateral cable bracing (page 90).
- Two-point equipment attachment—bolted to the building structure (page 93).

Rigid connection to the building structure using four threaded rods with lateral cable bracing

Equipment should have pre-installed brackets that can support the attachment to the building.

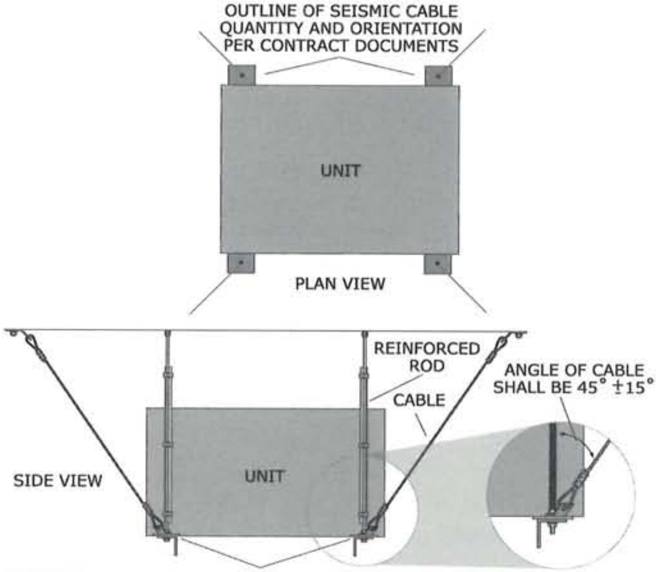


Figure 85: Rigid connection to the building structure.

Cables provide horizontal support for seismic loads and should not be installed to hang equipment.

Step 1: Attach the equipment to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 2: Add rod stiffeners

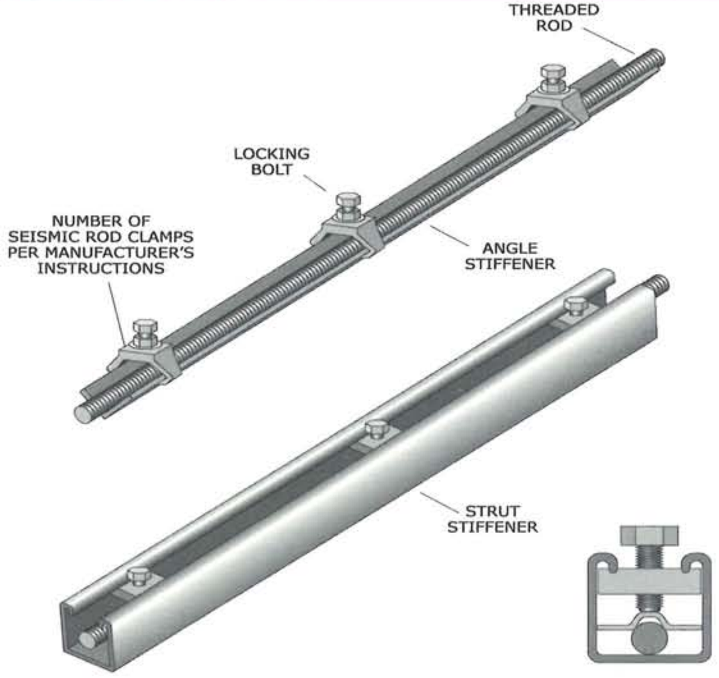


Figure 86: Rod stiffeners.

Step 3: Install anchors for cable attachment

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 4: Attach cable to the building structure

For cable assembly instructions, see Cables (page 134). For details on attaching cable to the building structure, refer to Attachment Details Connecting to Building Structure (page 102).

Step 5: Attach cables to equipment

For details on attaching cable to the equipment, see Figure 87 (below).

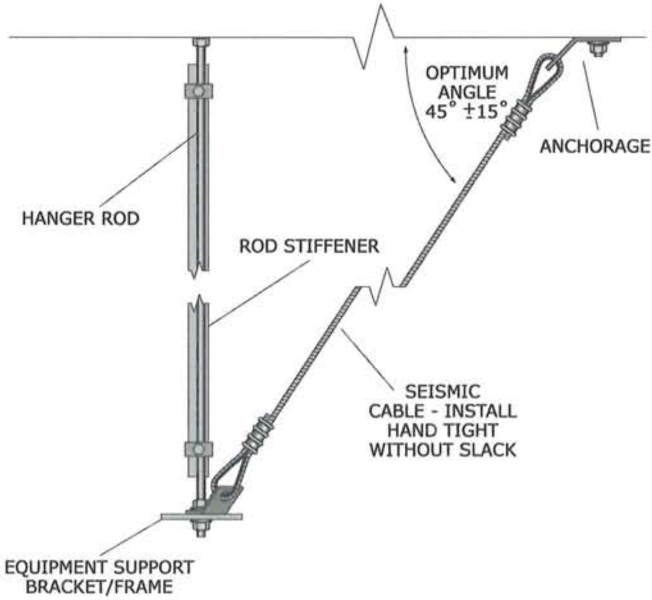


Figure 87: Attachment of cable to the equipment.

END OF DETAIL.

Rigid connection to the building structure using four threaded rods with lateral steel shaped bracing

Equipment may have pre-installed brackets for angle support attachments as shown in Figure 88 (below).

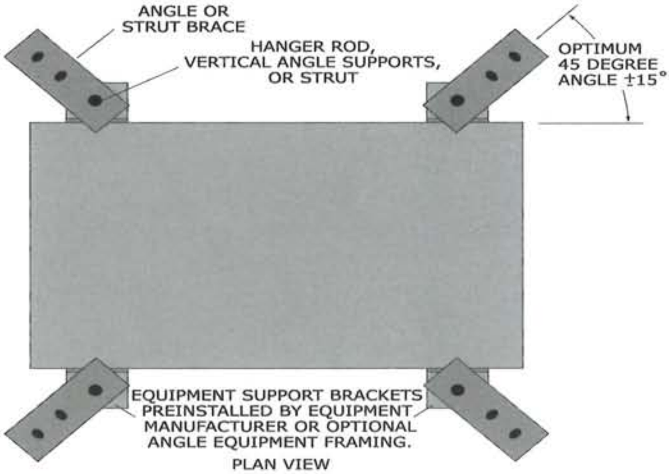


Figure 88: Rigid attachment of angles to the building structure.

Step 1: Attach the equipment to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107). Rod stiffeners are not required.

Step 2: Install anchors for angle or strut supports

For building structure attachment details, see Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 3: Attach angles or strut supports to the building structure

Step 4: Attach angles or struts to equipment

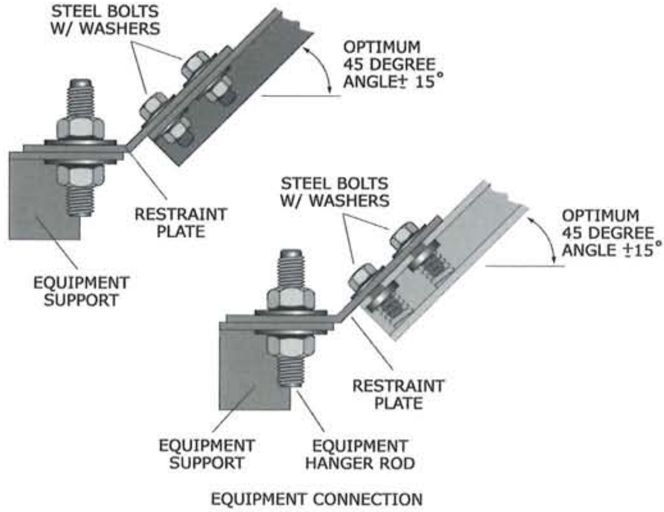


Figure 89: Attachment of angle or strut to the equipment.

END OF DETAIL.

Vibration-isolated connection to the building structure using a minimum of four threaded rods and lateral cable bracing

Equipment may have pre-installed brackets for angle support attachments. See Figure 90 (below) and Figure 91 (below).

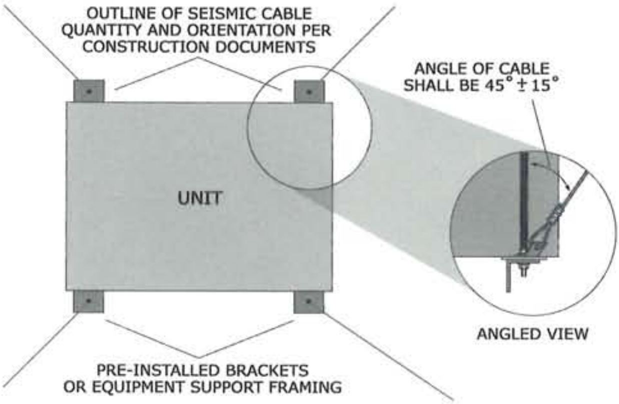


Figure 90: Plan view of vibration-isolated, suspended attachment to the building structure.

Side view shows vibration isolators, rods (without rod stiffeners), and cables.

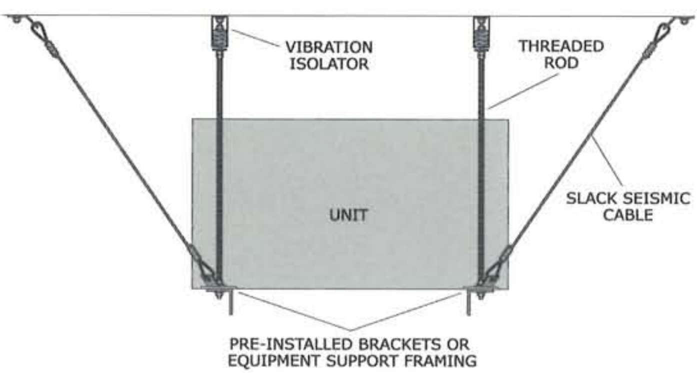


Figure 91: Side view of vibration-isolated, suspended attachment to the building structure.

Step 1: Attach equipment to the building structure using threaded rods, isolators and anchors

For isolator detail, see Figure 92 (below). For building structure attachment details, refer to Attachment Details Connecting to Building Structure (page 102).

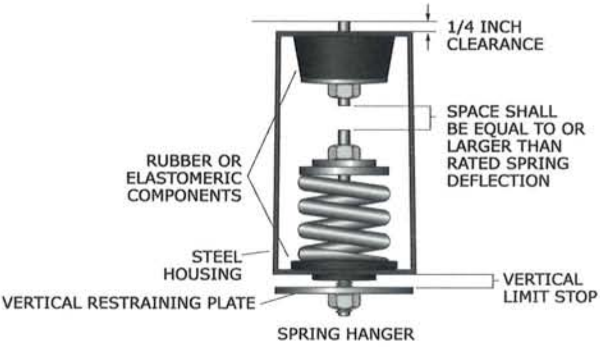


Figure 92: Isolator detail.

Step 2: Install anchors and attach cable to the building structure

For cable connection to the building structure, refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 3: Attach cables to equipment

For cable assembly, see Cables (page 134). For cable attachment to equipment, see Figure 93 (below).

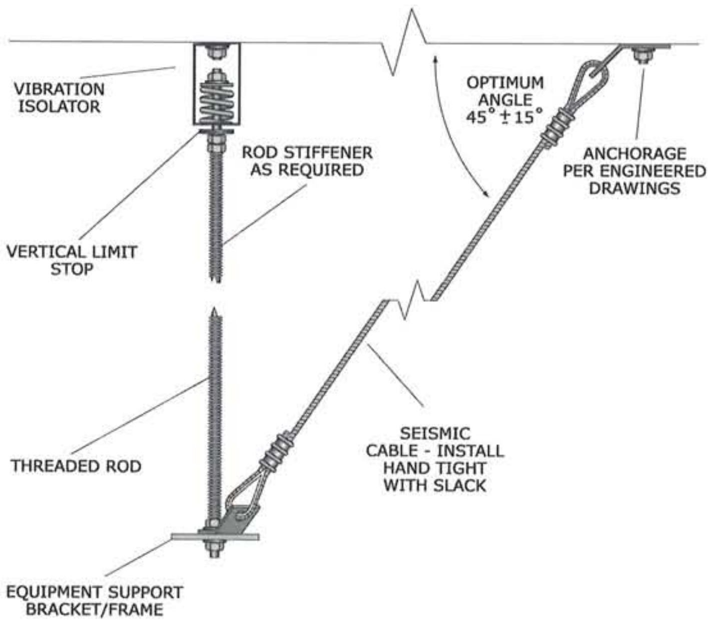


Figure 93: Attachment of cable/rod assembly to the equipment.

Step 4: Re-adjust vertical stop limit after support is fully loaded

Verify the adjustments of the vibration isolators with manufacturer's/industry manuals.

END OF DETAIL.

Two-point equipment attachment—bolted to the building structure

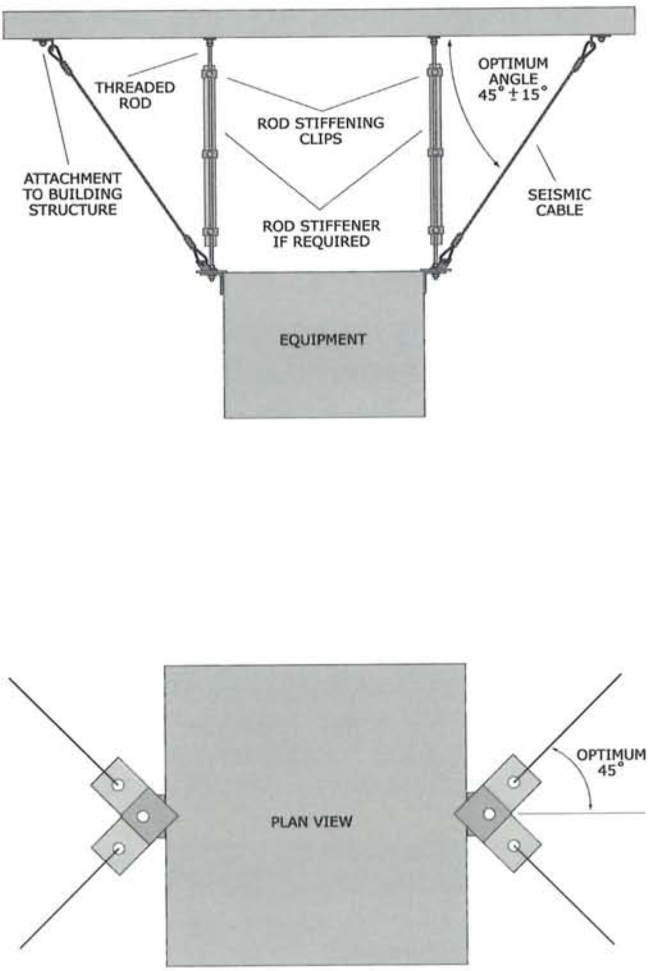


Figure 94: Two-point equipment attachment.

Step 1: Attach anchors and vertical rods to the building structure

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). Attach equipment to the vertical rods.

The equipment attachment should be located just above the center of gravity of the equipment to minimize swinging. It should be a rigid attachment with brackets to the equipment using double nuts and washers, especially if connected at the top as shown in Figure 94 (page 93).

Step 2: Attach rod stiffeners

For attachment details, refer to Figure 86 (page 86).

Step 3: Install anchors for cable attachment

For typical anchorage to different building construction, refer to Attachment Details Connecting to Building Structure (page 102). For details on bolting directly to building structure, see Anchors (page 107).

Step 4: Attach cables to the building structure

For cable assembly see Cables (page 134). For details on attaching cable to the building structure, refer to Attachment Details Connecting to Building Structure (page 102).

Step 5: Attach cables to equipment

The detail in Figure 87 (page 87) shows the cable attachment to the equipment.

END OF DETAIL.

Suspended by Steel Shapes

Double steel shaped supports with steel shaped lateral bracing

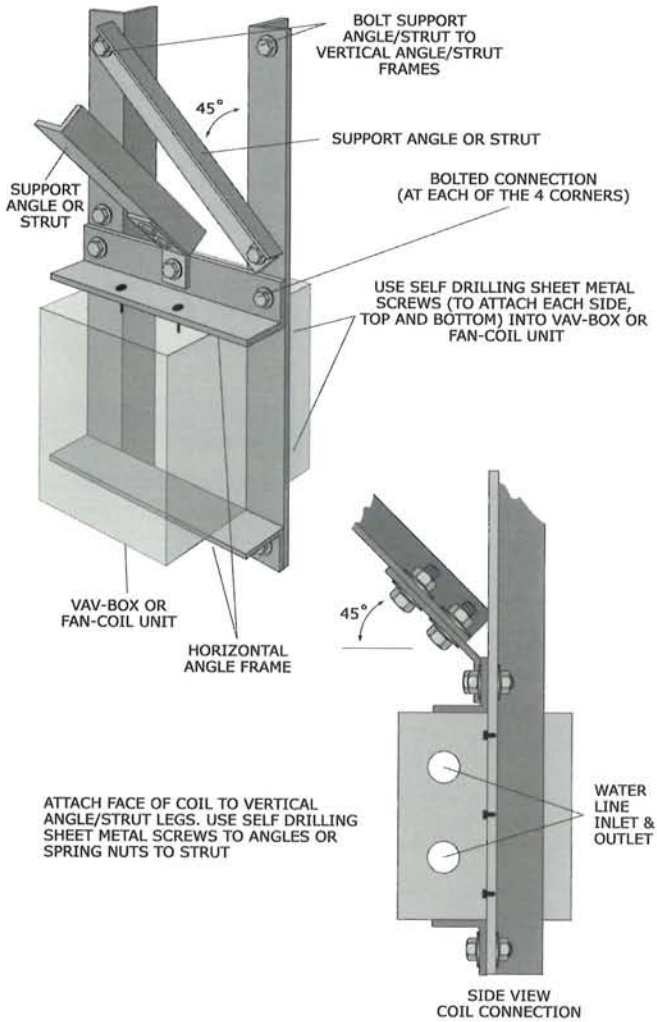


Figure 95: Attachment of double angles for equipment support.

Use this type of installation for duct-mounted coils, VAV boxes, or fan-coil units weighing less than 150 pounds.

Step 1: Attach anchors and vertical angles or strut to the building structure

For building structure attachment details, refer to Attachment Details Connecting to Building Structure (page 102).

Step 2: Attach horizontal framing

For attachment details, refer to Attachment Details Connecting to Building Structure (page 102).

Step 3: Install anchors for angle or strut restraints

For typical anchorage to different building construction, refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 4: Attach support angles or struts

One support is attached to the two vertical angles or struts. One support is attached to the building structure and to the top horizontal frame. For details on angle or strut attachment, refer to Attachment Details Connecting to Building Structure (page 102).

Step 5: Attach equipment

Attach equipment to the support assembly as shown in Figure 95 (page 95).

END OF DETAIL.

Suspended by Threaded Rods for In-line Pipe Equipment

This section decribes the following three types of in-line pipe equipment suspended by threaded rods:

- In-line pump (below).
- In-line air separator (page 99).
- In-line heat exchanger (page 100).

In-line Pump

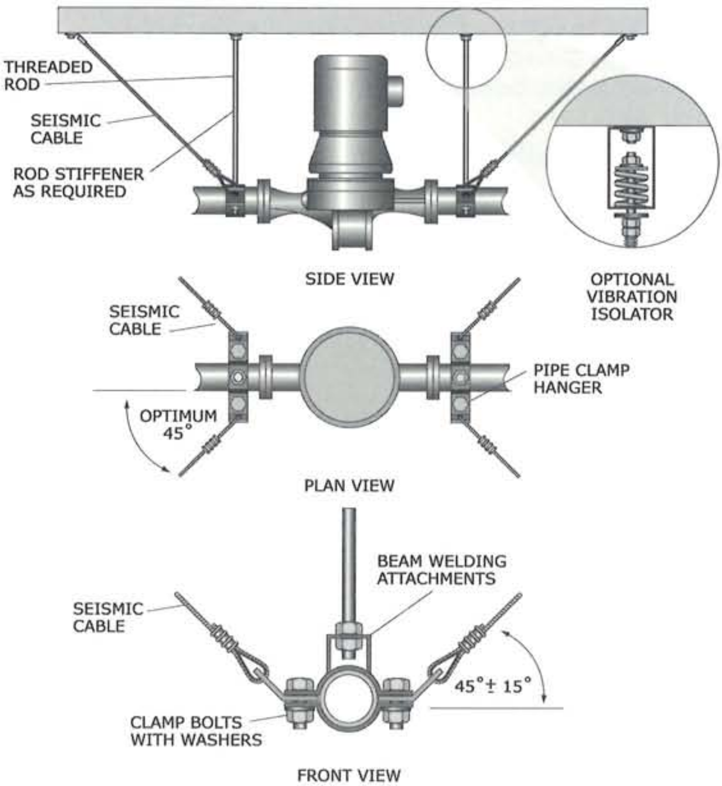


Figure 96: In-line pump.

Step 1: Attach pipe clamps to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 2: Add rod stiffeners

For rod stiffener details, refer to Figure 86 (page 86).

Step 3: Install anchors for cable bracing

Attach cable seismic brackets with anchors. For typical anchorage to different building construction, refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 4: Attach seismic cable

For cable assembly, see Cables (page 134).

END OF DETAIL.

In-line Air Separator

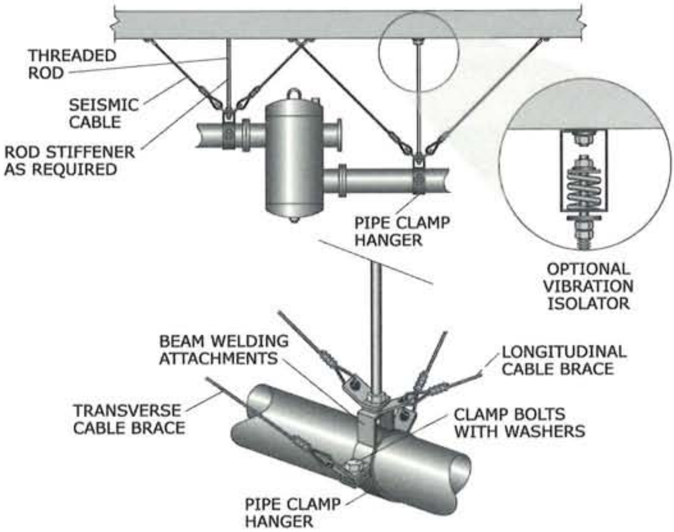


Figure 97: In-line air separator.

Step 1: Attach pipe clamps to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 2: Add rod stiffeners

For rod stiffener details, refer to Figure 86 (page 86).

Step 3: Install anchors for cable bracing

Attach cable seismic brackets with anchors. For typical anchorage to different building construction, refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 4: Attach seismic cable

For cable assembly, see Cables (page 134).

END OF DETAIL.

In-line Heat Exchanger

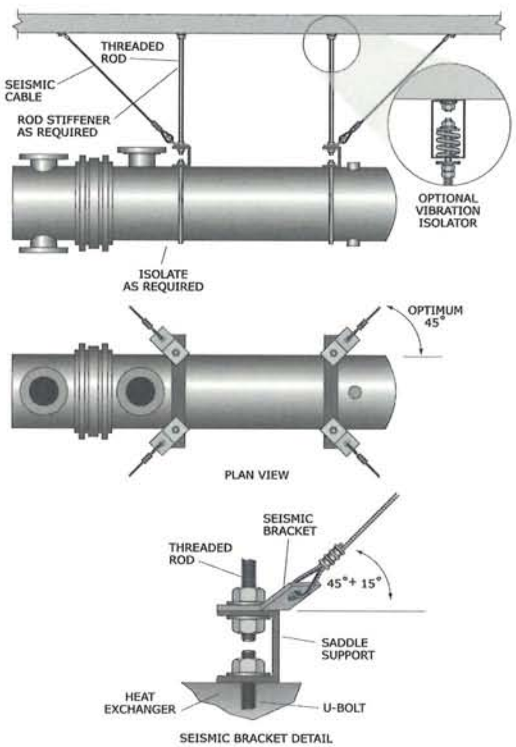


Figure 98: In-line heat exchanger.

Step 1: Attach pipe clamps to the building structure using threaded rods and anchors

Lay out all attachment points before anchoring, then refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 2: Add rod stiffeners

For rod stiffener details, refer to Figure 86 (page 86).

Step 3: Install anchors for cable bracing

Attach cable seismic brackets with anchors. For typical anchorage to different building construction, refer to Attachment Details Connecting to Building Structure (page 102). For instructions on installing anchors, see Anchors (page 107).

Step 4: Attach seismic cable

For cable assembly, see Cables (page 134).

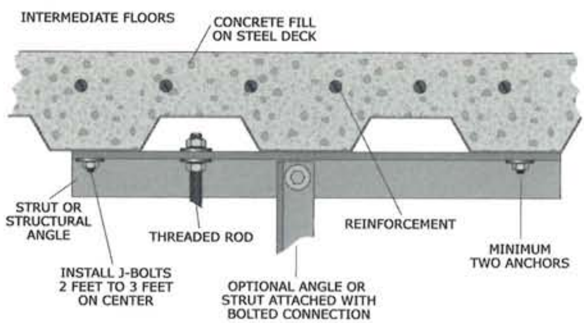
END OF DETAIL.

ATTACHMENT DETAILS CONNECTING TO BUILDING STRUCTURE

This section details seven types of attachments to building structures:

- To concrete fill on steel deck (this page).
- To wood beam (page 103).
- To I-beam (page 103).
- To bar joist (page 104).
- To concrete slab (page 104).
- Cable brace attachment (page 105).
- Steel shaped brace attachment (page 106).

To concrete fill on steel deck



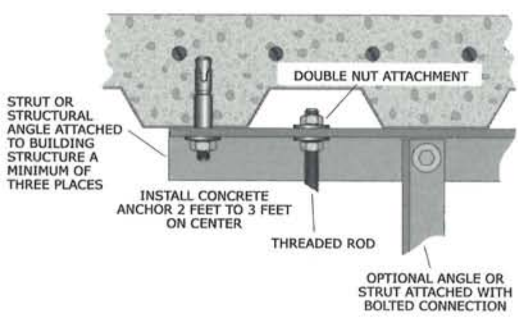


Figure 99: Post-installed anchor; concrete fill on steel deck.

END OF DETAIL.

To wood beam

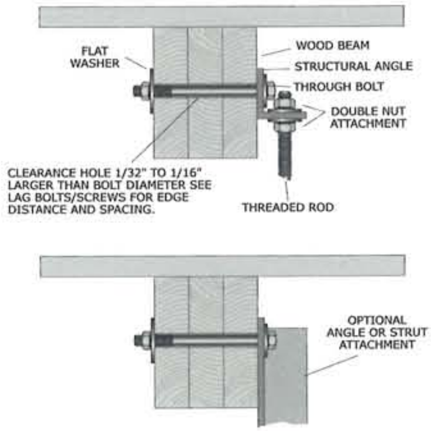


Figure 100: Wood beam construction.

For edge distance and spacing, see Lag Bolts (page 116).

END OF DETAIL.

To I-beam

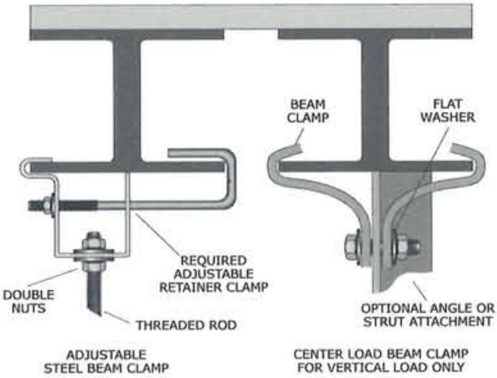


Figure 101: Steel I-beam construction.

Use center load beam clamps for vertical loads. Do not use for cables, rods, or structural members positioned at an angle.

END OF DETAIL.

To bar joist

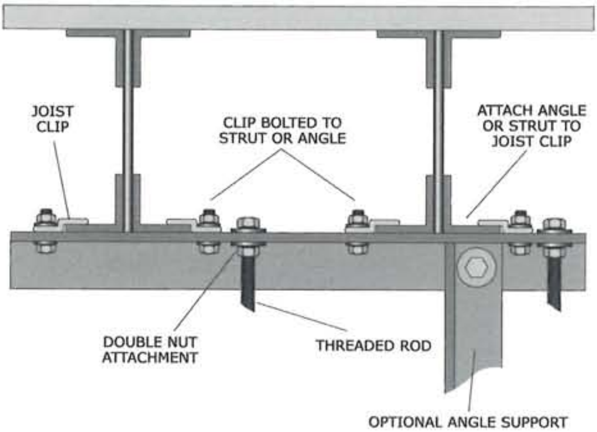


Figure 102: Bar joist construction.

Use center load beam clamps for vertical loads. Do not use for cables, rods, or structural members positioned at an angle.

END OF DETAIL.

To concrete slab

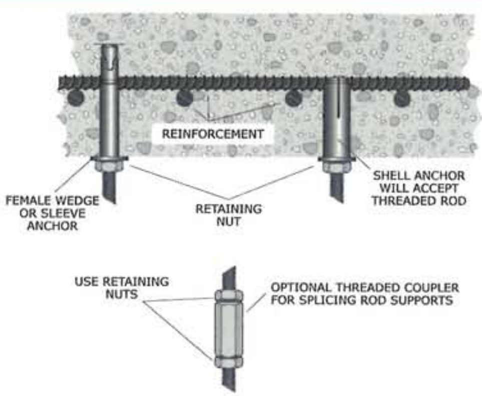


Figure 103: Concrete slab construction.

END OF DETAIL.

Cable brace attachment

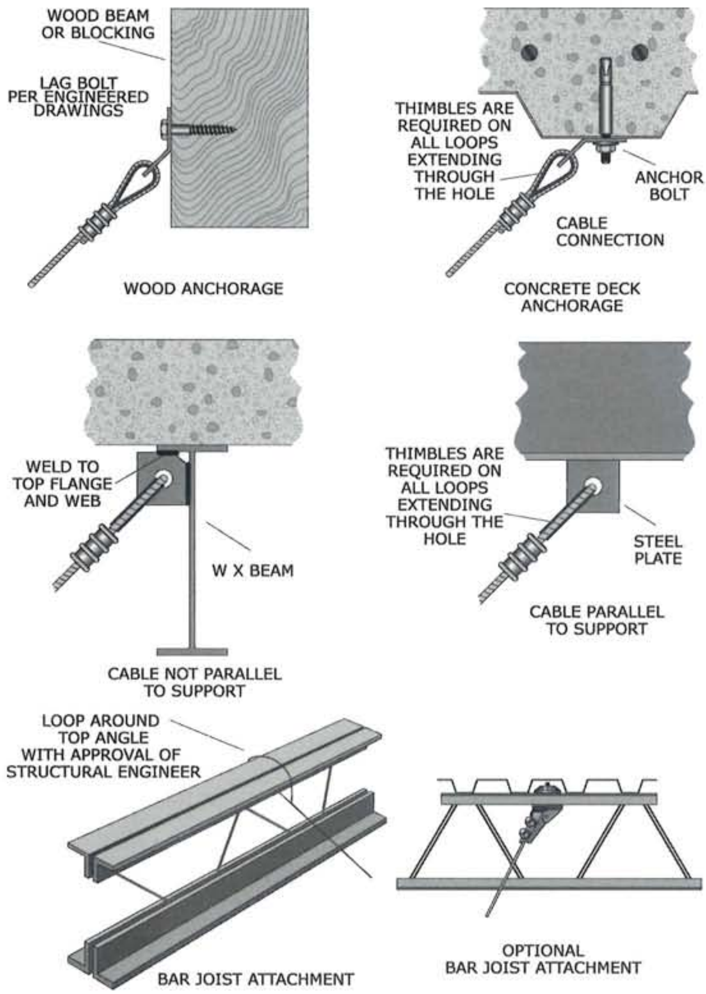


Figure 104: Attachment of cable brace to the building structure.

END OF DETAIL.

Steel shaped brace attachment

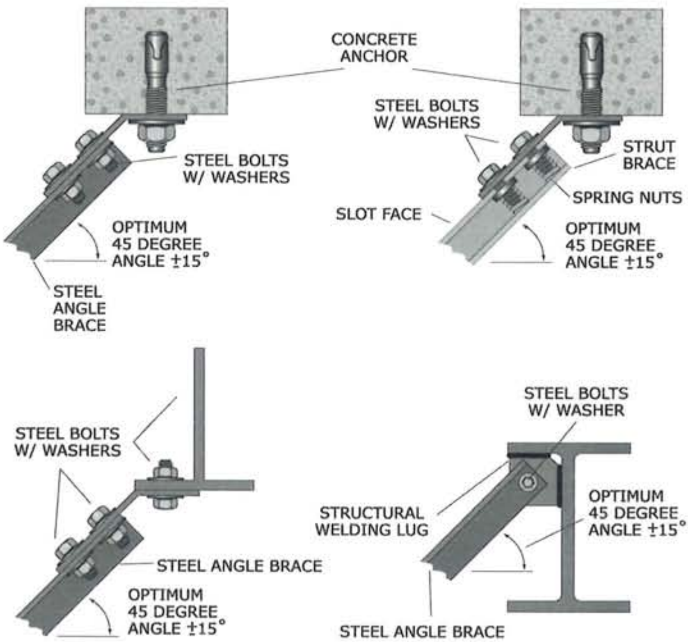


Figure 105: Attachment of angle or strut to the building structure.

END OF DETAIL.

ANCHORS

General Anchors

IMPORTANT: Installation methods depend on the type of anchor and the particular application. Always follow the anchor manufacturer's installation instructions.

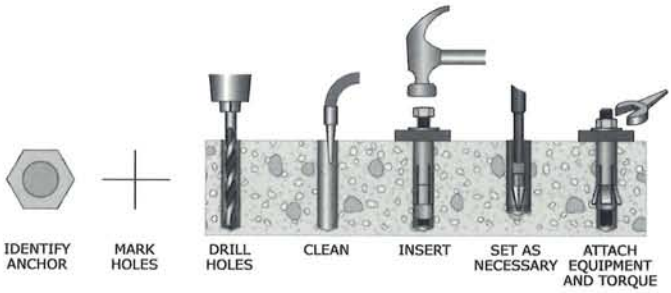
Figure 106: Types of anchors.

Some anchors must not be used with vibratory loads.

Step 1: Determine the type of anchor

Using Figure 106 (page 107), identify the anchor recommended for your application. Anchors 1-6 are post-installed anchors and instructions for installing them begin on this page. Anchors 7-11 are specialty anchors and instructions are shown on pages 114 to 133.

The various steps for installing anchors into concrete, brick, and concrete block are shown below.



Non-Adhesive Anchors

Adhesive Anchors

Figure 107: Summary of installation steps.

Approved construction documents may require special inspection to torque anchors or for proof load using hydraulic rams.

Step 2: Determine where to drill the hole

To determine anchor locations for the equipment you are installing, follow the instructions for the equipment, bracing and attachment you are using (pages 16 to 106). Coordinate the equipment connections and hole locations with the location of any steel reinforcements or tendons.

Determine the depth and location of any steel reinforcement or tendons *before* drilling. This may require relocating equipment slightly to avoid the reinforcement.

FOR POST-TENSIONED (PRE-STRESSED) BUILDINGS, LOCATE THE TENDONS BEFORE DRILLING. EXTREME DAMAGE MAY OCCUR IF A TENDON IS NICKED OR CUT.

When using electronic locating devices to find reinforcement and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precision of the test unit and record the results. For example: *agreed upon mark +/- ¼" location vertical, horizontal, and depth +/- ½".*

Coordinate the location of anchors with the edge of the concrete, construction joints, and other anchors.

Do not install the anchor too close to the edge of the concrete base. Typically, the anchor's distance from the edge is 1½ times the embedment depth.

Do not install an anchor too close to another anchor. Typically, the minimum spacing between anchors is two times the anchor's embedment depth.

Step 3: Drill the hole

Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.

Do not drill holes into concrete at an angle.

For wedge, undercut and sleeve anchors, drill the hole deeper than the required embedment depth.

The required hole depth may be different from the embedment depth. See Figure 108 (page 110).

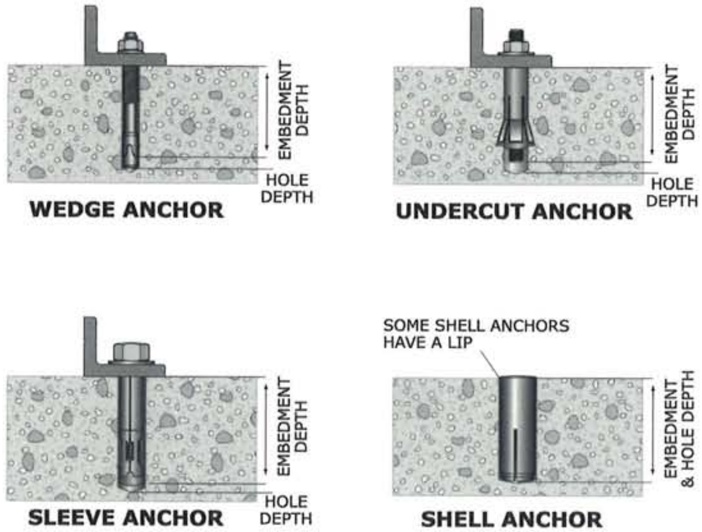


Figure 108: Embedment depth and hole depth of four anchor types.

The depth of the concrete base must be at least one inch greater than the hole you are drilling.

Some undercut anchors require an even deeper concrete base.

If you strike steel reinforcement when drilling, you must have the damage inspected. As directed, fill the hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see Figure 109 below).

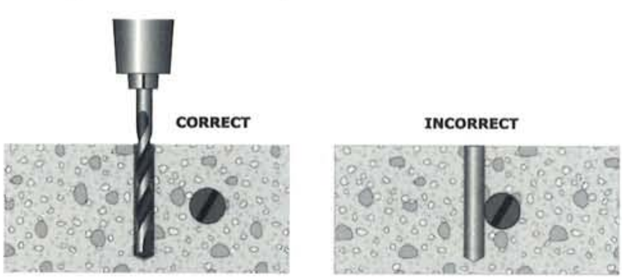


Figure 109: Drilling into concrete with rebar.

Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use a brush.

See the anchor manufacturer's instructions for cleaning the hole.

CLEANING IS IMPORTANT: a "dirty" hole can significantly reduce an anchor's performance.

Step 5: Insert the anchor

If you are installing any anchor *other than* an adhesive anchor, drive the anchor into the hole with a hammer or use a wrench rotor hammer for concrete bolts.

IMPORTANT: DO NOT DAMAGE THE THREADS DURING INSTALLATION. DO NOT FORCE THE ANCHOR. If you use a larger hammer than recommended by the manufacturer, you may damage the anchor.

If you are installing an adhesive anchor, insert the capsule or inject non-capsule adhesive into the hole. Slowly rotate the anchor into place as shown in Figure 110 (below).

Figure 110: Adhesive anchor installation.

If you have installed a wedge or sleeve anchor, go to Step 7 (page 113).

Step 6: Setting adhesive, shell and undercut anchors ONLY

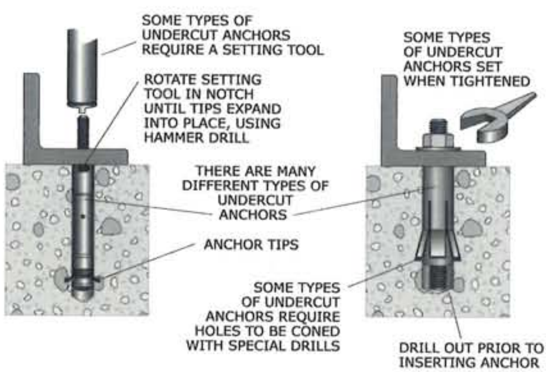
Adhesive Anchor: Allow enough time for the adhesive to fully cure. The curing process may take a long time. See the manufacturer's instructions.

Shell Anchor: Drive the prescribed setting tool into the anchor until the setting tool shoulder meets the edge of the anchor, as shown below. See the manufacturer's instructions.

SHELL ANCHOR

Figure 111: Set shell anchors.

Undercut Anchor: Use special tools provided by the anchor manufacturer to set the anchor, as shown below. See the manufacturer's instructions.



UNDERCUT ANCHORS

Figure 112: Set undercut anchors.

Step 7: Set the equipment and tighten the anchors

Set the equipment in place. Check for gaps. Gaps under the equipment must not be greater than 1/8" as shown below. If the gap is greater than 1/8", dry pack the gap with grout and repeat this step.

Figure 113: Acceptable gap for grouted plate.

For anchor bolts larger than 3/8", the equipment housing should be reinforced using a structural angle bracket as shown in Figure 114 (below).

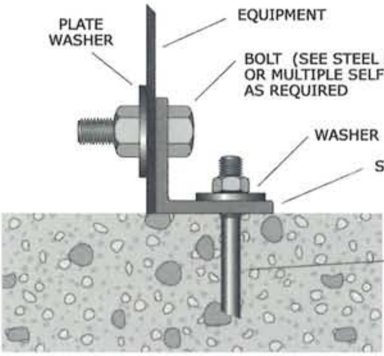


Figure 114: Installing a reinforcing angle bracket to equipment.

Tighten the anchor bolt to the correct torque setting in the manufacturer's instructions or approved construction documents. Use a calibrated torque wrench.

END OF DETAIL.

Cast-in-place Anchors

Cast-in-place anchors are embedded in the concrete when the floors or walls are poured. Bolts are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the anchors can be determined from approved construction documents.

Step 1: Move the equipment into place

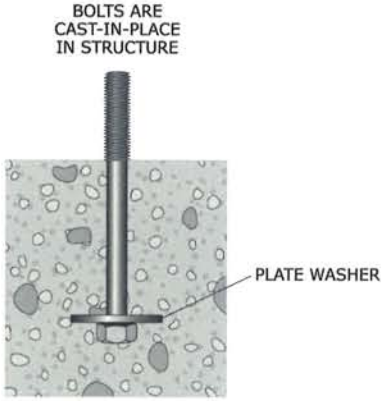


Figure 115: Bolting equipment to cast-in-place anchors.

Step 2: Secure equipment

Once the equipment is in place, apply washers and nuts and then tighten.

Tighten the anchor bolt to the correct torque setting in the manufacturer's instructions or approved construction documents.

Use a calibrated torque wrench or turn-of-nut method (see Table 5, page 127).

END OF DETAIL.

Lag Bolts

Lag bolts are used to attach equipment or steel shapes to wood structures. The size and location of the anchors can be determined from approved construction documents (see Figure 116, below).

- The edge distance for the non-loaded side is 1½ times the bolt diameter.
- The edge distance for the loaded side is 4 times the bolt diameter.
- The spacing between bolts is 4 times the bolt diameter.
- The end distance is 7 times the bolt diameter.

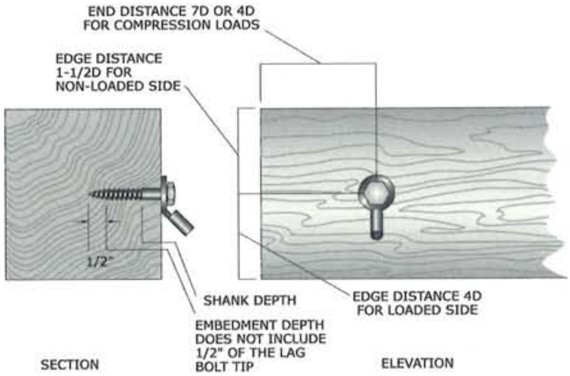


Figure 116: Spacing requirements for wood lag bolts.

Figure 116 is allowed for cable attachments. If a strut is attached to wood, both edge distances are considered loaded and require 4 times the bolt diameter.

Do not anchor to the end grain.

Step 1: Mark the location of the lag bolts

Lead holes and clearance holes are not required for lag bolts that are 3/8" or smaller. If the lag bolt is smaller than 3/8", go to Step 4 (page 116).

Step 2: Drill a clearance hole

Drill a hole with a drill bit the same size as the shank of the bolt. The depth of the hole is the same as the length of the unthreaded shank that will extend into the wood (see Figure 116, page 115).

Step 3: Drill a lead hole

Drill a hole with a drill bit that is 60% to 70% of the diameter of the shank of the bolt. The depth of the hole is the same as the embedment depth of the bolt.

Step 4: Move the equipment or steel shape into place

Step 5: Install the lag bolt with a wrench

You may use soap or other lubricant on the lag bolt.

DO NOT USE A HAMMER TO INSTALL LAG BOLTS.

Step 6: Tighten the bolt

Hand-adjust the lag bolt until there is firm contact between the lag bolt and connected metal components. Hand tools may be used to bring the lag bolt and metal components into contact. Following contact, tighten nut as shown in Table 5 (page 127).

END OF DETAIL.

Masonry and Drywall Anchors

Step 1: Determine the type of anchor

1. ADHESIVE (KEYED) ANCHORS WITH SCREENS FOR BRICK OR BLOCK

2. CONCRETE SCREW FOR HOLLOW BLOCK IN BED JOINT

3. UMBRELLA ADHESIVE FOR HOLLOW BLOCK FACE MOUNTED

4. TOGGLE BOLT FOR HOLLOW BLOCK FACE MOUNTED

5. SLEEVE ANCHOR FOR HOLLOW BLOCK IN BED JOINT OR FOR GROUT-FILLED BLOCK CENTER FACE MOUNTED

6. THROUGH BOLT FOR HOLLOW BLOCK OR IN-FILLED BLOCK OR SHEET ROCK

7. WEDGE ANCHOR GROUT-FILLED BLOCK CENTER FACE MOUNTED

8. LAG BOLTS FOR DRYWALL ON WOOD STUDS

9. DRILL IN SHEET METAL SCREWS FOR DRYWALL ON METAL STUDS

Figure 117: Types of masonry and drywall anchors.

Step 2: Determine where to drill the hole

Anchors shown in Figure 117 (page 117) must be installed in specific areas of hollow block and in-filled block. See Figure 118 (below) for approved anchor hole locations when using any of the concrete block anchors shown in Figure 117.

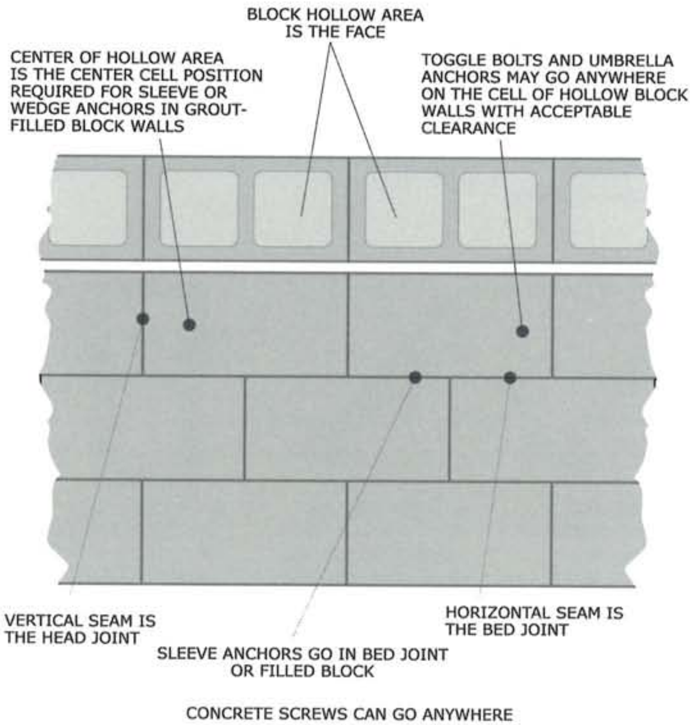


Figure 118: Block wall locations.

The location of the anchors should be coordinated with the block webs, or centered in the cell face, *and properly spaced from other anchors.*

DO NOT POSITION THE HOLES IN THE HEAD JOINT. Carefully note the location of anchors in the face location, centered face location, and bed joint as they apply to different anchors.

Find webs in block walls, reinforcements in grout-filled walls, or studs in drywall. Location of through-bolts: Avoid webs in concrete block and studs in drywall walls.

Location of lag bolts and sheet metal screws in drywall: Install in a wood or metal stud as appropriate.

Determine the depth and location of any steel reinforcement in grout-filled block walls or brick before drilling. This may require relocating equipment slightly to miss reinforcement.

When using electronic locating devices to find reinforcements and tendons, make sure you know the limitations of the device. Calibrate and test with a known standard or location to confirm accuracy. Check the area of concern in two directions. Inform the contractor performing the work of the precision of the test unit and record the results. For example: *agreed upon mark +/- ¼" location vertical, horizontal, and depth +/- ½".*

Step 3: Drill the hole

Drill the right-sized hole for the anchors. Use the appropriate ANSI-rated drill bit for the application.

Use masonry drill bits for brick and block.

DO NOT CUT STEEL REINFORCEMENT WHEN DRILLING HOLES.

If you strike steel reinforcement when drilling, you must have the damage inspected. As directed, fill the hole with approved grout and select a new location according to minimum spacing requirements. Drill a new hole (see Figure 109, page 110).

Holes for concrete screws are smaller than screw size. See the manufacturer's instructions for specific requirements.

Step 4: Clean out the hole

Drilled holes must be cleaned before you can insert the anchor. Use clean, dry compressed air to blow out dust and debris. The type of anchor or application also may require you to use a brush.

See the anchor manufacturer's instructions for cleaning the hole.

CLEANING IS IMPORTANT: a "dirty" hole can significantly reduce an anchor's performance.

Step 5: Insert the anchor

The following anchors use different insertion methods:

- Adhesive screen anchor in a brick wall or hollow block wall (this page).
- Adhesive anchor in a hollow block wall (page 121).
- Concrete screw (page 122).
- Toggle bolt (page 122).
- Concrete anchor (sleeve anchor or wedge anchor) (page 123).
- Drywall anchor (lag bolts and sheet metal screws) (page 123).

Adhesive screen anchor in a brick wall or hollow block wall

See the anchor manufacturer's instructions before connecting the anchor to a brick or hollow block wall.

A screen insert is shown in Figure 119 (page 121). Insert the screen in the wall. Inject the adhesive. Slowly insert the anchor with a twisting motion.

Screens may be filled with adhesive before inserting the screen into the hole.

For details on installing adhesive anchors in a brick wall, see Figure 120 (below). Similar installation applies to hollow block walls. Adjust the anchor by hand while the adhesive sets.

DO NOT TOUCH THE ANCHOR WHILE THE ADHESIVE IS CURING.

Figure 119: Brick/block wall insert.

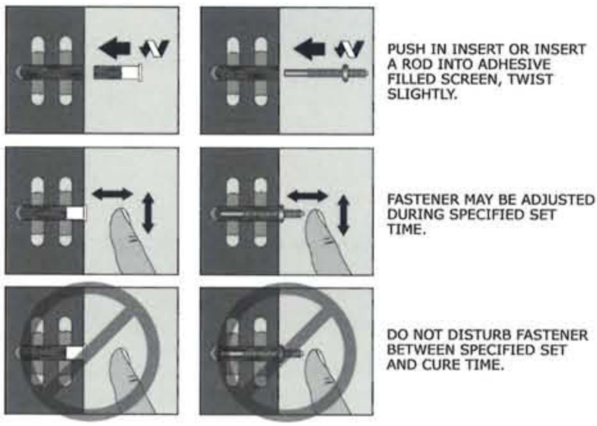


Figure 120: Brick wall adhesive anchor.

Adhesive anchor in a hollow block wall

See the anchor manufacturer's instructions before connecting the anchor to a hollow block wall.

Push an umbrella anchor into the hole until the umbrella unfolds in the block cavity (Figure 121, page 122). Inject adhesive into the umbrella. Slowly insert stud or fastener with a twisting motion.

DO NOT LEAK ADHESIVE ON THE THREADED PORTION OR CLEAN WITH SOLVENT. The threaded area must be free of debris to attach to a threaded rod or steel bolt.

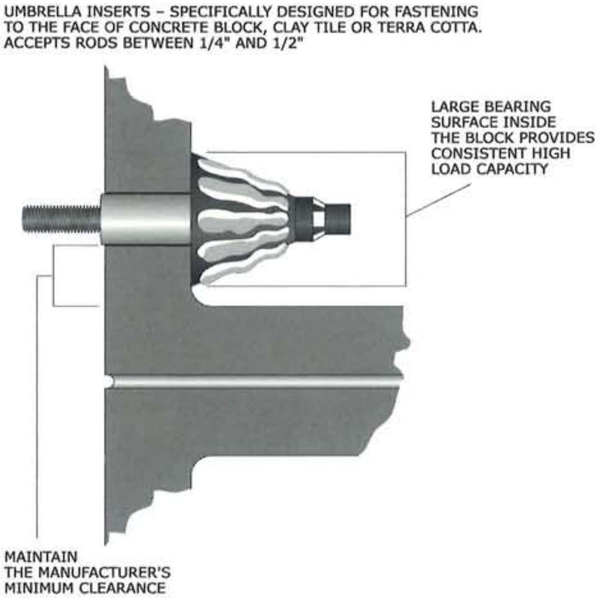


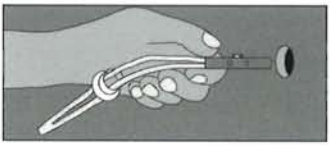
Figure 121: Umbrella anchor in a hollow block wall.

Concrete screw

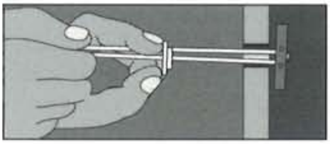
Drill bits may be specifically sized for each manufacturer, and typically are smaller in diameter than the nominal or fractional diameter of a screw. Install a concrete screw with a rotary drill and bolt the head attachment.

Toggle bolt

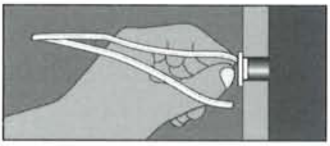
Hold the toggle flat alongside the plastic straps and slide the channel through the hole. Slide the holding ring toward the wall until the channel is flush with the wall. Cut off the straps at the holding ring. Insert the bolt with a rotary drill over the bracket or equipment mounting. See Figure 122 (page 123).



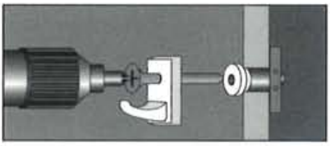
DRILL HOLE. HOLD TOGGLE FLAT ALONGSIDE PLASTIC STRAPS, SLIDE THROUGH HOLE.



WITH ONE HAND, PULL RING SO METAL CHANNEL RESTS FLUSH BEHIND WALL. SLIDE PLASTIC CAP ALONG STRAPS WITH OTHER HAND UNTIL FLANGE OF CAP IS FLUSH WITH WALL.



PLACE THUMB BETWEEN PLASTIC STRAPS. PUSH SIDE TO SIDE SNAPPING OFF STRAPS FLUSH WITH WALL.



INSERT BOLT THROUGH ITEM TO BE ATTACHED AND TIGHTEN UNTIL FLUSH WITH FIXTURE. MINIMUM CLEARANCE BEHIND WALL: 1-7/8" (48MM).

Figure 122: Toggle bolt installation.

DO NOT OVER-TIGHTEN.

Concrete anchor (sleeve anchor or wedge anchor)

Use a hammer to drive the anchor in the hole.

DO NOT FORCE THE ANCHOR. If you use a hammer larger than recommended, you may damage the anchor.

To determine the embedment depth of post-installed anchors, see Figure 108 (page 110).

Drywall anchor (lag bolts and sheet metal screws)

Use a rotary drill to insert the anchor.

DO NOT OVER-TIGHTEN.

Step 6: Set the anchor (adhesive only)

Allow enough time for the adhesive to harden and adhere to the concrete. *This may take several hours.*

Step 7: Set the equipment and tighten the anchors

Tighten the anchor bolt to the proper torque setting as shown in the anchor manufacturer's instructions or approved construction documents.

In-filled block walls may have gaps in the grout fill or the grout may slightly crack, requiring anchors to be installed in the center of the cell.

If the grout cracks severely, or if you miss a grouted block, the anchor will not tighten and will pull out. If it pulls out, move the anchor to a new centered cell location.

END OF DETAIL.

Power-Actuated Anchors

Step 1: Determine type of anchor

DRIVE PIN THREADED STUD

Figure 123: Two types of power-actuated anchors.

Authorities having jurisdiction may require a license to use power-actuated anchors.

Refer to the Anchor Selection Guide (page 148) for additional information.

Step 2: Determine where to place the fastener

Follow the manufacturer's recommendations for minimum slab thickness and best location.

Step 3: Install anchor

Using tools provided by the anchor manufacturer, install the anchor at the desired location. Follow all the manufacturer's instructions. Also see Power-Actuated information in the Anchor Selection Guide (page 148).

For threaded rods, follow Step 4.

When using drive pins, install the pin with the strap or wire to complete the installation.

Step 4: Set equipment and tighten

Tighten the anchor nuts over equipment brackets on the threaded rods.

END OF DETAIL.

Steel Bolt Connections

The three ways to attach bolted connections are:

- Connecting the base of the equipment to an angle bolted to a concrete floor (this page).
- Bolting two structural steel shapes together (page 128).
- Bolting a threaded rod to steel shapes or strut (page 129).

Connecting the base of the equipment to an angle bolted to a concrete floor

Step 1: Preparation

Determine the bolt size or sheet metal screw and material requirements from approved construction documents or the manufacturer's instructions.

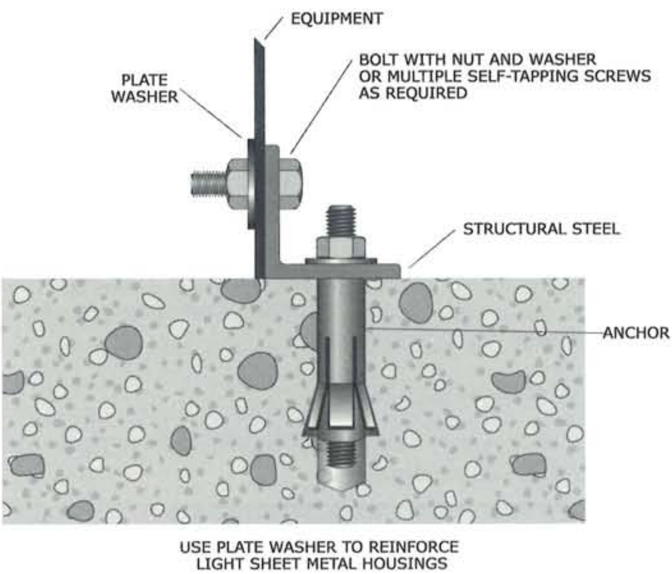


Figure 124: Bolting equipment to an angle.

Step 2: Locate holes

Use pre-drilled holes wherever possible. Holes may not have been pre-drilled at the attachment locations shown in the instructions. In these cases, carefully drill new holes in the correct locations.

Use caution when drilling into equipment. Internal components can be damaged. DO NOT DRILL OVERSIZED HOLES.

Step 3: Install bolts, washers, and nuts

Once the equipment is in place, apply washers and nuts and then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents.

For turn-of-nut tightening hand-adjust the bolt snug tight where there is firm contact between the bolt and connected metal components. Hand tools may be used to bring the bolt an meta components into contact. Following contact, tighten the nut as shown below.

Length of Bolt	*Additional Tightening*
Up to and including 4 diameters	1/3 turn
Over 4 diameters and not more than 8 diameters	1/2 turn
Over 8 diameters and not more than 12 diameters	2/3 turn

Table 5: Turn-of-nut, hand-adjusted tightening.

Bolting two structural steel shapes together

Step 1: Preparation

Determine the bolt size and material requirements from approved construction documents or the manufacturer's instructions.

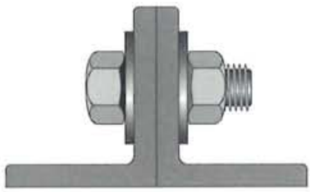


Figure 125: Bolting structural shapes.

Step 2: Locate holes

Carefully drill new holes in the structural steel shapes.

Step 3: Install bolts, washers, and nuts

Apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents. Use a calibrated torque wrench or turn-of-nut method (see Table 5, page 127).

END OF DETAIL.

Bolting a threaded rod to steel shapes or strut

A threaded rod is used with suspended equipment. This section includes attachment to the equipment and attachment to the building structure (page 102).

Step 1: Preparation

Determine the threaded rod size from approved construction documents or the manufacturer's instructions.

The three different ways to attach the threaded rod are shown in Figure 126 (below).

Step 2: Attach the top connection of the threaded rod

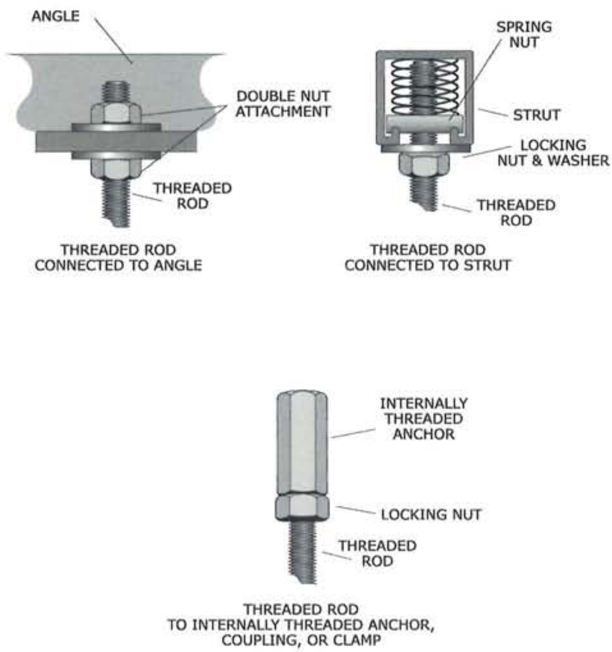


Figure 126: Attaching the top connection of the threaded rod.

Apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents. Use a calibrated torque wrench or turn-of-nut method (see Table 5, page 127).

Step 3: Attach threaded rods to equipment brackets

Equipment without attachment brackets requires additional steel shapes for connections to the building structure and/or roof.

Once the equipment is in place, apply washers and nuts, then tighten.

Tighten the anchor bolt to the correct torque setting shown in the manufacturer's instructions or approved construction documents. Use a calibrated torque wrench or turn-of-nut method (see Table 5, page 127).

END OF DETAIL.

Welding

Before welding, refer to approved construction documents and specifications, seismic restraint submittals, and manufacturer's instructions.

Attaching equipment to embedded plates: Plates are embedded in the concrete during the floor or wall pour. Plates are firmly held in place while the concrete is poured to maintain proper alignment and position. The size and location of the plate can be determined from construction drawings. See Figure 127 (below) for weld locations.

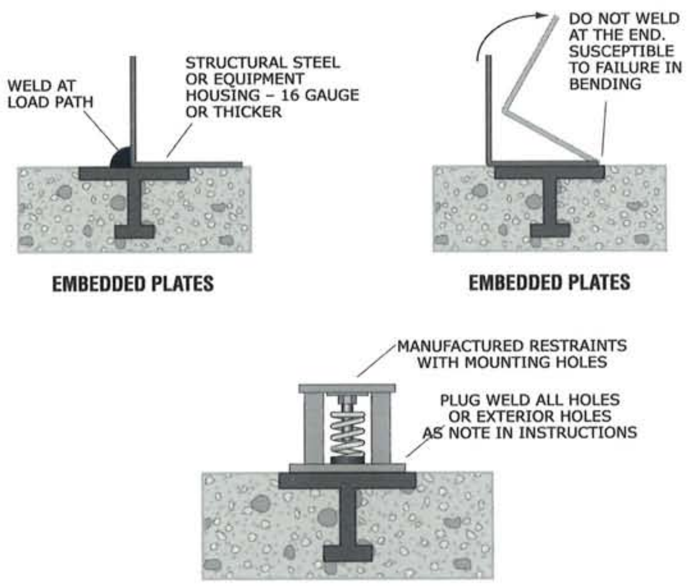


Figure 127: Welding to embedded plates.

Attaching structural shapes and plates: Shapes and plates are welded to provide equipment attachment. All weld base material must be thick enough for the weld size specified.

Step 1: Determine the weld material, shape, and dimensions for each piece

Step 2: Fit the material to ensure proper weld joint preparation

Step 3: Clean the surfaces

Surfaces must be dry and free of galvanized coating, hot-dipped or rust inhibitor, paint, scale, rust, oil, grease, water, and other foreign material for a minimum of one inch from the estimated toe of the weld.

Step 4: Weld the materials

The weld must be as prescribed in the welding procedure specifications (WPS).

> WPS for shop and field pre-qualified weld joints and weld joints qualified by test must be prepared for review and approval before fabrication. All welding procedure items such as base metals, welding processes, filler metals and joint details that meet the requirements of AWS D1.1 will be considered prequalified. Any change or substitution beyond the range or tolerance or requirements for pre-qualification will be qualified by test pre-AWS D1.1.

! **DO NOT WELD OVER PAINT. You may paint after welding has cooled to room temperature.**

Step 5: Inspect the weld

Make sure the surface is free of slag, dirt, grease, oil, scale, or other contaminants.

Welds cannot have cracks. Adjacent layers of weld metal and base metal must be thoroughly fused together.

All craters must be filled to the full cross-section except outside the effective weld length.

Underrun must not exceed 1/16". Undercut must not exceed 1/16" for any 2" per 12" weld or 1/32" for the entire weld.

Surfaces must be free of coarse ripples, grooves, abrupt ridges, and valleys. The faces of fillet welds must be flat or slightly convex.

END OF DETAIL.

Anchor Sizes for Suspended Equipment

Rigidly attach equipment to building structure rods and cables according to Table 6 (below). Torque anchors according to the manufacturer's instructions.

Vertical threaded rod	*Quantity*	*Anchors per Rod*
1/2" rod with rod stiffener	One on each corner	1

Rod anchor	*Embedment (in.)*	*Minimum Edge Distance*
1/2" wedge	2-1/4"	3-1/2"
1/2" sleeve	2-1/4"	3-1/2"
3/8" lag bolt to wood beam	2"	2" to edge of wood and 3" from end
1/2" steel bolt	N/A	1"

Cable	*Quantity*	*Anchors per cable*
3/16" seismic cable	4 at 45 degrees at each corner	1

Cable anchor	*Embedment (in.)*	*Minimum Edge Distance (in.)*
1/2" wedge	2-1/4"	3-1/2"
1/2" sleeve	2-1/4"	3-1/2"
3/8" lag bolt to wood beam	2"	2" to edge of wood and 3" from end
1/2" steel bolt	N/A	1"

Table 6: Suspended equipment anchor sizes for rigid connections.

SPECIAL CASES

Cables

The three ways to assemble cable connections are by using:

- Bolts with center holes (page 135).
- Ferrule clamps (page 136).
- Wire rope grips (page 138).

Other end fittings may be acceptable.

Cables should be installed at a 45-degree slope. Where interferences are present, the slope may be a minimum of 30 degrees and a maximum of 60 degrees.

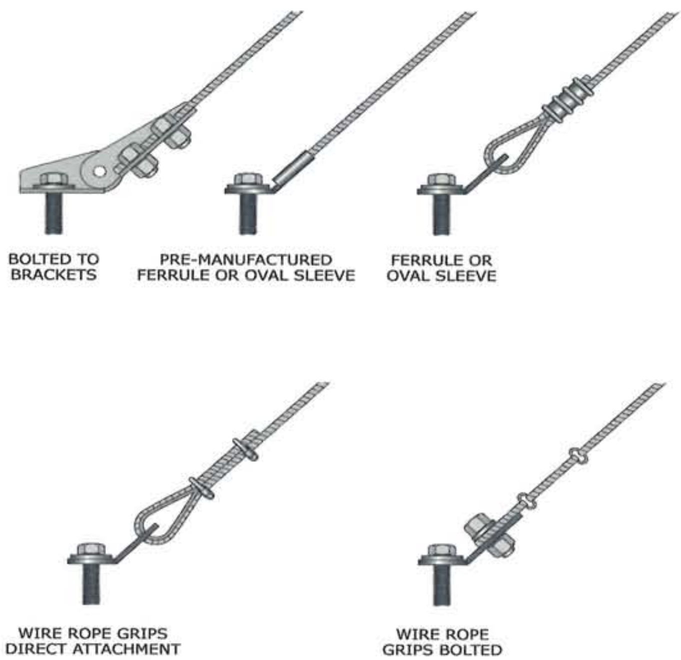


Figure 128: Cable attachments.

Bolts with center holes

The manufacturer provides this type of cable assembly, along with the cables, mounting bolts with holes, and brackets that attach directly to the building structure or equipment frame. Assemble the cable as shown below.

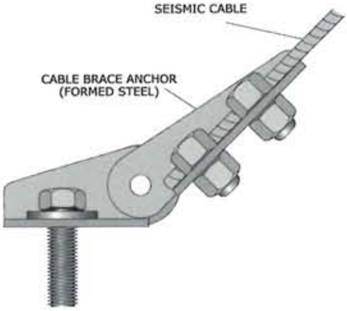


Figure 129: Cable attached with bolts to a bracket.

Step 1: Drill anchor holes in the building structure as required

Step 2: Attach brackets to both the building and the equipment frame

Step 3: Cut the cable to desired length and slide it through the holes in the bolts

Step 4: Tighten the cable

For rigid connections, pull the cable hand tight. Pull the cable hand-tight and let out 1/8" slack for vibration-isolated components. Avoid using too much tension or too much slack.

Step 5: Torque bolts

Refer to the manufacturer's instructions.

Overtorque of bolts may cause damage to cables.

END OF DETAIL.

Ferrule clamps

Ferrule clamps may be connected to various types of attachments. Figure 130 (below) and Figure 131 (page 137) show attachments and identify the parts, ferrules or sleeves and thimbles, used in the assembly.

Ferrules must be made of steel, zinc-plated copper, or steel alloys (including stainless steel). Do not use aluminum ferrules.

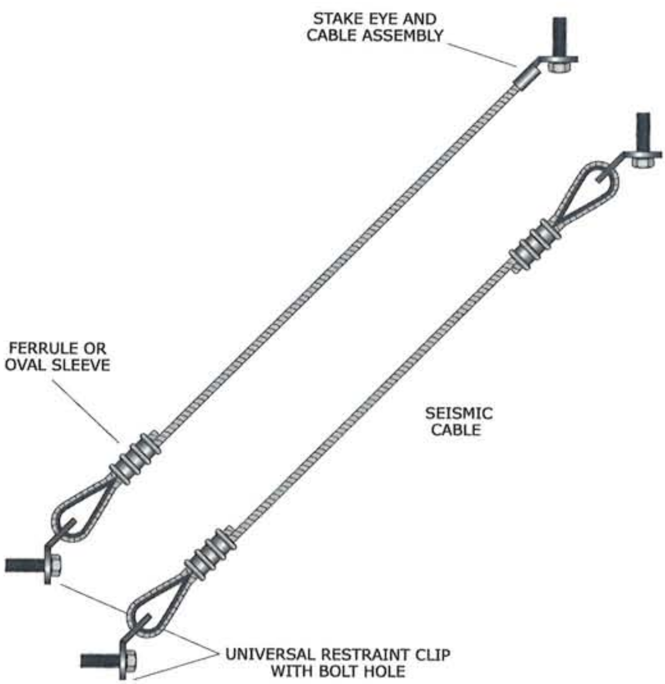


Figure 130: Ferrule assemblies.

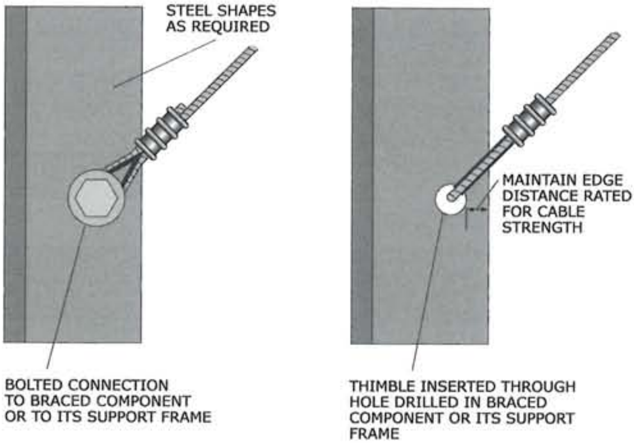


Figure 131: Ferrule attachments.

Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes

Install brackets with mounting holes to the structure. Attach cables to the top of cord angles. See Attachment Details Connecting to Building Structure (page 102).

Step 2: Cut the cable to the desired length and slide the oval ferrule (sleeve) onto the cable

Step 3: Wrap the cable around the thimble and pass it through the mounting bolt or holes and back through the ferrule

Step 4: Tighten the cable

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

Step 5: Crimp the ferrule or oval sleeve two or three times as specified in the cable or ferrule manufacturer's instructions

Use crimp tools and gauges specified by the manufacturer. Crimp and verify the depth of the crimp using a gauge.

END OF DETAIL.

Wire rope grips

Installing cables attached with wire rope grips is similar to attaching ferrule clamps, as shown below.

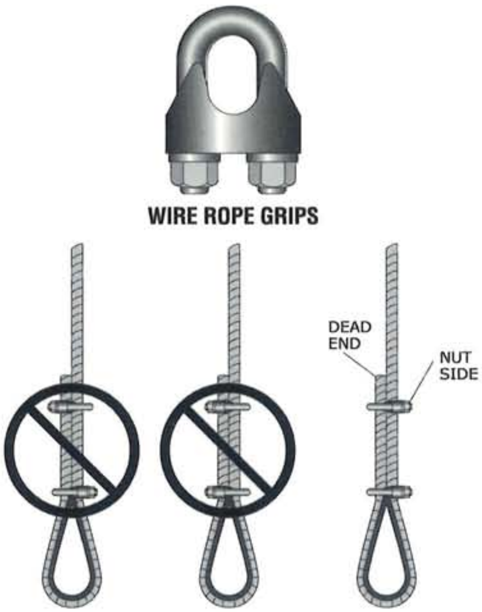


Figure 132: Wire rope grip assemblies.

Note that the nut side must be located opposite the dead end of the cable.

Step 1: Install brackets with mounting holes, eye-bolts, or drill mounting holes

Step 2: Cut cable to the desired length and slide three wire rope grips and thimbles onto the cable

Step 3: Pass the cable through the mounting bolt or holes provided and then back through each of the wire rope grips

Use thimbles for all cable installations with wire rope grips.

Step 4: Tighten the cable

For rigid connections, pull the cable tight. For isolated components, leave a small amount of slack. Avoid using too much tension or too much slack.

Step 5: Torque all bolts evenly

Use the turn-of-nut tightening method described in Step 3 of Steel Bolt Connections (page 126).

DO NOT OVER-TIGHTEN.

END OF DETAIL.

Flexible Connections and Expansion Joints

Flexible connections are required when vibration-isolated equipment is attached to rigidly supported piping systems or ductwork.

Flexible connections are also required when rigidly mounted equipment is attached to unrestrained piping systems or to unrestrained ductwork systems.

Expansion joints are required when piping systems or ductwork span two different building structures or when entering an isolated building.

Flexible Connectors

The four flexible connectors are:

- Rubber joint duct connector (this page).
- Braided hose pipe connector (page 141).
- Rubber hose pipe connector (page 141).
- Rubber hose connector with control rods (page 141).

Follow manufacturer's instructions to install connectors.

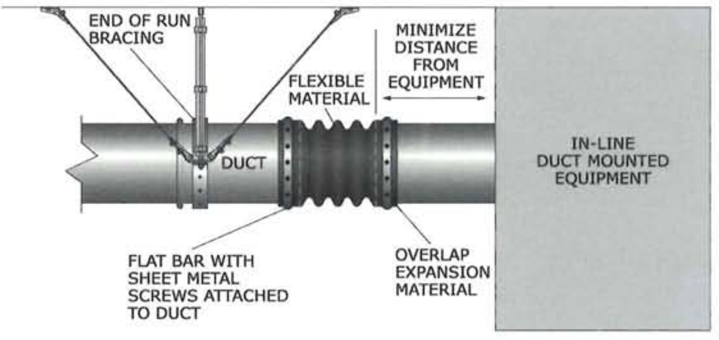


Figure 133: Rubber joint duct connector.

Rectangular ducts may use slip joints.

End-of-run seismic braces are required at flexible connections.

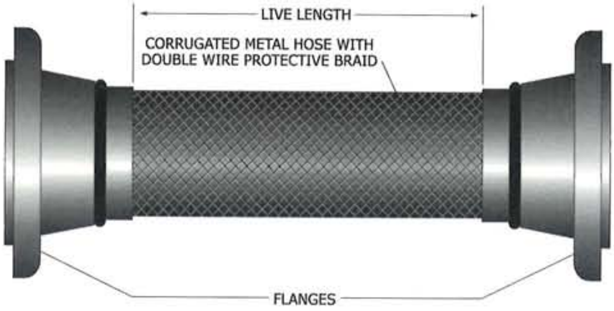


Figure 134: Braided hose pipe connector.

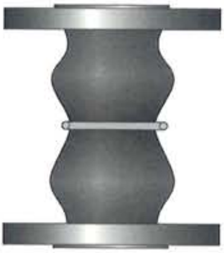


Figure 135: Rubber hose pipe connector.

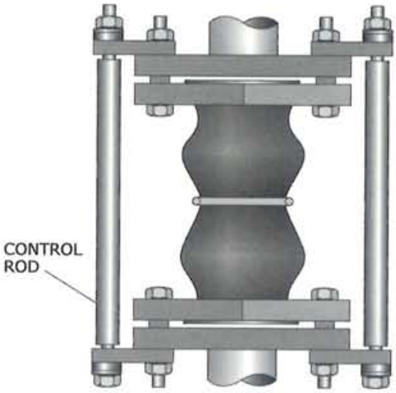


Figure 136: Rubber hose connector with control rods.

END OF DETAIL.

Expansion Joints

The four expansion joints are:

- Braided hose expansion joint (this page).
- Double-socket expansion joint (this page).
- Expansion joint above floor (page 143).
- Expansion joint between a separation (page 143).

Step 1: Verify clearance allowed by expansion joint with movement of the two systems

Layout all attachment points before making final connections.

End-of-run seismic braces are required at expansion joints.

Step 2: Run pipe as required by approved construction documents

Figure 137: Braided hose expansion joint.

Figure 138: Double-socket expansion joint.

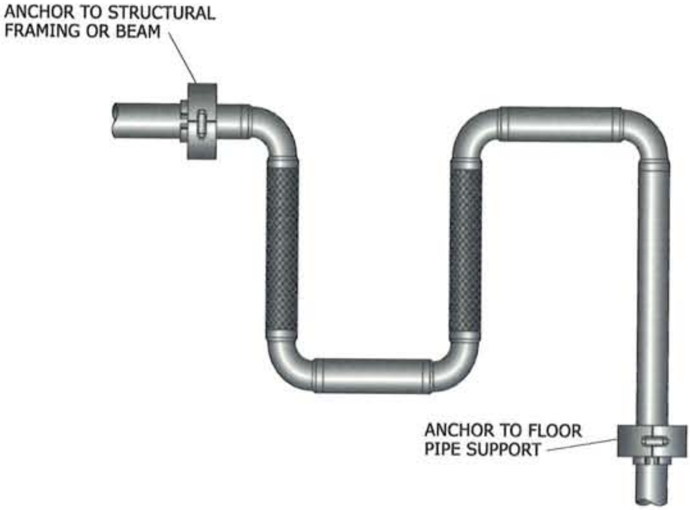


Figure 139: Expansion joint above floor.

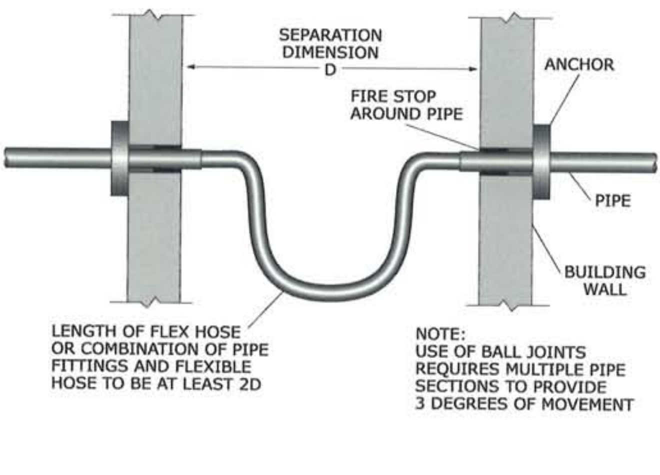


Figure 140: Expansion joint between a separation.

END OF DETAIL.

Valves and Valve Actuators

There are many ways to brace valves and valve actuators. Valves usually do not require special braces and usually are required only in the horizonal direction. Approved construction documents must identify all directions of bracing required.

Rigid or flexible pipe braces near the valve are common. These braces should be installed for specifically bracing the valve and not for bracing the piping system. The piping system should have an independent bracing system.

See Pipe Bracing Details and Installation Instructions (page 54) for pipe braces that can be used near the valve bodies.

There are two types of valve bracing:

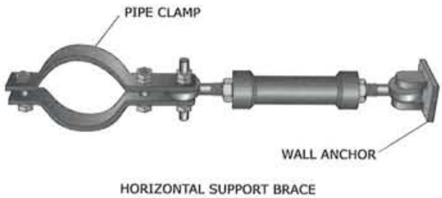
- Pipe bracing (page 145).
- Valve bracing (page 146).

Valve actuator seismic braces must be identified on the approved construction documents. These braces are typically unique and depend on the installation and type of valve actuator.

Valve actuators that are directly on top of the valve only require horizontal braces. Heavy actuators located on the side may require additional vertical braces, as detailed in:

- Valve actuator bracing (page 147).

Pipe Bracing



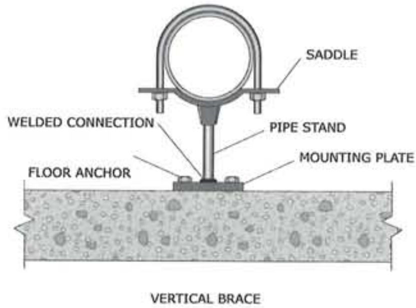


Figure 141: Pipe bracing detail.

Step 1: Run piping as shown on the approved construction documents

Lay out all attachment points before making final piping connections.

Step 2: Verify lengths used for the pipe bracing

Temporarily fit bracing as necessary.

Step 3: Attach mounting plates to the building structure

For instructions on installing anchors, see Anchors (page 107).

Step 4: Assemble brace

END OF DETAIL.

Valve Bracing

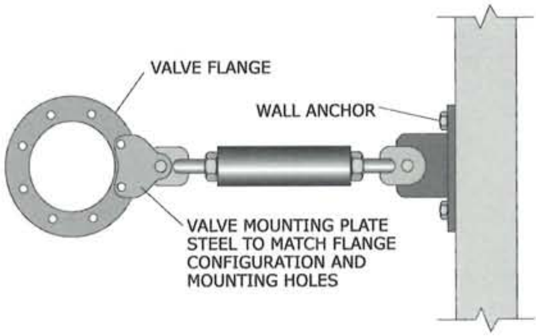


Figure 142: Transverse bracing directly attached to valve.

Step 1: Run piping as shown on the approved construction documents

Lay out all attachment points before making final piping connections.

Step 2: Verify lengths used for the pipe bracing

Temporarily fit bracing as necessary.

Step 3: Attach mounting plates to the building structure

For instructions on installing anchors, see Anchors (page 107).

Step 4: Assemble bracing

END OF DETAIL.

Valve Actuator Bracing

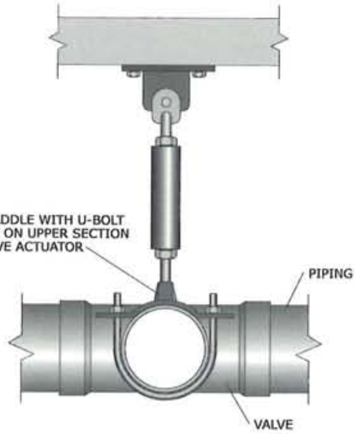


Figure 143: Valve actuator bracing.

Step 1: Run piping as shown on the approved construction documents

Lay out all attachment points before making final piping connections.

Step 2: Verify lengths used for the pipe bracing

Temporarily fit bracing as necessary.

Step 3: Attach mounting plates to the building structure

For instructions on installing anchors, see Anchors (page 107).

Step 4: Assemble bracing

END OF DETAIL.

ANCHOR SELECTION GUIDE

Power-Actuated	
Description	Warning
Threaded Studs Used in cases where the fastened equipment is to be removed later, or where shimming is required. Threaded studs for concrete have a 0.140" to 0.180" shank diameter, with typical penetration of 3/4" (minimum) to 1-1/2" into concrete. Threaded studs for steel plate applications have a 0.140" to 0.180" shank diameter when the steel plate thickness is 3/16" or greater. **Drive Pins** Used to directly fasten equipment for permanent installation. Drive pins used for concrete have a 0.140" to 0.180" shank diameter, with typical penetration of 3/4" minimum to 1-1/2" into concrete. Drive pins for steel plate applications have a 0.140" to 0.180" shank diameter when the steel plate thickness is 3/16" or greater.	**Safety is the primary concern when using power-actuated tools (PAT). PAT tools pose the greatest risk to the operator and others in the area of use. Observe the following safety precautions:** Typically not used for equipment weighing more than 40 pounds. Never allow a tool to be used until the operator is properly trained for the specific tool and application. Never use a tool unless all safety features are functioning properly. Always have the operator and others around wear the proper safety devices. Never use more powerful loads than required for the particular application. Always be aware of the potential of the fastener passing through the substrate or being deflected from its intended target. Make sure that all areas are clear behind and around the target area. Have an action plan in place to properly handle and dispose of misfired loads. Always make sure the tools are low velocity and not standard velocity. (Standard velocity tools are not typically allowed on most jobsites because of the danger.) **Authorities having jurisdiction may require a license to use power-actuated anchors.**

Adhesive	
Description	**Warning**
Capsule Spin-In Adhesive mixes in the hole when the anchor is drilled by a rotary hammer drill only. Various strengths and types of rods or fasteners can be used. Multiple types of coatings on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.	Do not over-spin during installation. The rod must have a roof cut end with a single or double 45-degree angle/bevel for mixing. The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong odors during the curing process. Check the MSDS sheets or with your supervisor to determine if masks are required.
Capsule Hammer-in Adhesive mixes in the hole when the rod is driven by a hammer. Various strengths and types of rods or fasteners can be used. Multiple types of coatings on rods are available. Most commonly used in concrete; some might be suitable for use in other substrates. Most capsules cure quickly compared to epoxy.	The hole must be clean and dry to achieve the maximum strength. Rod must be clean and must not be disturbed during curing. Many capsules produce strong odors during the curing process. Check the MSDS sheets or with your supervisor to determine if masks are required.

Adhesive (cont.)	
Description	**Warning**
Epoxy Used by mixing two or more components with a mixing nozzle at the point of application. Can be used with multiple forms of fasteners or as an adhesive. Many brands can be used in wet, damp, or dry conditions. Many formulas are allowed for use for USDA food processing areas. Some may be able to be used overhead. Permitted many times in freeze-thaw and severe weather conditions. Allows minimal edge distance and anchor spacing. Typical shelf life greater than that of other adhesives used for anchoring. Not as susceptible to damage from high storage temperatures.	Typically requires long curing times compared to that of other adhesives. Can be virtually odor free or can emit a strong odor, depending on the formula. Can be difficult to apply if the epoxy is thick. Generally not suggested for use at temperatures below 32 degrees F. Most epoxies require holes to be cleaned to obtain maximum values. Check the MSDS sheets or with your supervisor to determine if masks are required.
Acrylic Adhesive Dispenses and cures quickly. Some adhesives can be used overhead. Some adhesives can be installed in damp or water-filled holes. Typically can be used with many fastening devices such as threaded rod, dowels, and anchors.	Many types of acrylics produce a strong odor during the curing process. Others have a minimal odor. Check the MSDS sheets or with your supervisor to determine if masks are required.
Adhesive Undercut Anchors Used in heavy-duty applications where substrate is of poor quality.	Generally purchased from the manufacturer as a complete anchoring system. Any substitution of materials must be authorized before installation.

Externally Threaded	
Description	**Warning**
Heavy Duty Undercut Used in heavy-duty applications. Typically two types: self-undercutting and adhesive. Self-undercutting types use a special undercutting drill bit similar to heavy-duty sleeve anchors except that they fill a cavity greater than the initial hole diameter.	May require special tools and specific drill bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.
Wedge Anchor The most common concrete anchor for heavy- to light- duty applications. Many configurations are available for most applications. Made from a variety of materials.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.
Heavy Duty Sleeve Anchor Expansion anchor for heavy-duty requirements.	A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If re-assembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or be detached from the expansion cone, requiring anchor replacement. These conditions are not visible.

Externally Threaded (cont.)	
Description	Warning
Center Pin Anchor Medium-duty expansion anchor. The anchor is correctly installed when the pin is completely inserted. Installation procedures are simple; no torque is required to set the anchor.	Typically designed for static loads and not used with reciprocating engines, motors or in situations where vibrations are present.
Sleeve Anchor Universal anchor for light- to medium-duty applications. Multiple head designs fit many applications and can be installed in masonry.	A large hole is required for this anchor. Some anchors have metric diameters. Some have multiple parts that can be unassembled. If re-assembled improperly, the anchor may not perform properly. If the nut is removed after the stud is inserted in the hole, the stud could be partially separated from the expansion cone, causing a reduction in anchor strength, or be detached from the expansion cone, requiring anchor replacement. These conditions are not visible.
Concrete Bolts *(continued on next page)* Concrete bolts are recommended for use in dry interior applications. Concrete bolts may be acceptable in some cases for temporary use in exterior applications. Not all concrete bolts used in resisting earthquake or wind loads are appropriate and may be beyond the scope of the anchors abilities.	Maintain equal or greater than minimum edge distance spacing specified for concrete bolts or apply reduction factors if applicable. The embedment depth is the distance from the concrete surface to the bottom of the screw anchor. Maintain minimum slab thickness. Use ONLY a specific manufacturer's recommended method of installation.

Externally Threaded (cont.)	
Description	Warning
Concrete Bolts *(cont.)* Concrete bolts should not be subjected to vibratory loads such as those encountered by supports for reciprocating engines, crane loads, and moving loads. Concrete bolts are limited to installation in uncracked concrete masonry. Cracking may occur from anchor location in tension zone of concrete member, and anchors subjected to seismic loads, wind loads, or moving loads. Concrete bolts are limited to non-fire-resistive construction unless appropriate data is submitted demonstrating that anchor performace is maintained in fire-resistive situations.	NEVER substitute one manufacturer's concrete bolt installation instructions for another manufacturer's instructions. DO NOT ASSUME one manufacturer's instructions are the same as another manufacturer's instructions. Some manufacturers use different diameter drill bits for the same nominal diameter concrete bolt. Use the proper diameter drill bit before installation. When a specific screw anchor manufacturer's drill bit diameter is not used, a reduction of capacity must be accounted for in the calculations. Other manufacturers may *recommend* the use of ANSI B212 matched diameter drill bits for use with their concrete bolts. Some manufacturers may allow power tools for installation and others may not. Some screw anchor manufacturers recommend not using an electric impact wrench when re-using the same hole. Some manufacturers allow piloting a new anchor hole; 1 or 2 additional applications or re-uses are possible. If the manufacturer allows the screw anchor to be reused, inspect for excessive wear or the capacity of the screw anchor.

Internally Threaded	
Description	Warning
Internally Threaded Undercut Anchor Used in heavy-duty applications. Typically come in two types: self-undercutting and those using a specialized undercutting drill bit. Anchors have internal threads. Shallow embedment and small edge distances and spacing are possible.	May require special tools and specific drill bits. Typically cannot be used at variable embedment depths. Can be complicated to install. May be difficult to verify proper installation.
Shell Anchor Flush-mount or sub-surface internally threaded anchor for medium- to light-duty applications. Comes in fractional and metric sizes and is available in a variety of materials.	A special setting tool is required and must be supplied by the anchor manufacturer. The setting tool is designed for each anchor size and style.
Others Similar to the wedge concrete anchor and used in heavy- to light-duty applications. Many configurations are available to fit most applications. Made from a variety of materials.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.

Light Duty Fastenings	
Description	**Warning**
Drive Pin (nail) Anchors (metal and plastic) Light-duty anchor with fast and easy installation in many substrates.	Use only for static loads. Typically not used in overhead applications. **DO NOT USE FOR SEISMIC RESTRAINT**
Concrete Screws Medium- to Light-Duty A variety of lengths and diameters are available. Often used for temporary anchorage.	Typically not used in situations where extensive vibrations are present. Requires the use of a special drill bit (some metric) supplied by the anchor manufacturer.
Special Style Head Wedge (ring) anchor Wedge anchor with integrated connection (head) designed for tie wires or suspended ceilings.	Typically designed for static loads and not used with reciprocating engines or in situations where vibrations are present.
Single and Double Expansion Shields Multi-purpose anchor used in concrete, Concrete Masonry Unit (CMU), brick, or stone. This anchor distributes fairly even pressure, making its use popular in CMU, brick, and natural stone. Typically used in conjunction with machine bolts, which can be removed and replaced.	Anchor material is malleable and the threads can be stripped. **DO NOT USE FOR SEISMIC RESTRAINT**

Light Duty Fastenings (cont.)	
Description	Warning
Lead Expansion Anchors Similar to expansion shields, but typically considered light-duty. Many can be used with a variety of screws or bolts. Quick and simple to install. Can be used in concrete, CMU, brick, or stone.	Anchor material is malleable and the threads can be stripped. Anchor should not be used in any applications. **DO NOT USE FOR SEISMIC RESTRAINT**
Toggle or "Molly"-type Anchors Light- to medium-duty anchor with easy installation in many substrates. No drilling is required for some anchor types or in some substrates. Some anchors are supplied with bolts or screws. Anchors are made from variety of materials and colors including plastic, zinc alloys, and steel.	May require a large hole. Anchor may or may not be reusable if the bolt is removed. Severe damage to the substrate can result if these anchors are removed after installation.

GLOSSARY

A

Adhesive anchor – A smooth or deformed steel bar or threaded rod, set in a predrilled hole in hardened concrete or masonry (including masonry units and mortar joints) that derives its holding strength from a chemical bonding compound placed between the wall of the hole and the embedded portion of the anchor.

Anchor – A device for connecting equipment and attachments to the building structure.

Attachments – Support systems used to connect equipment, pipe, conduit, or ductwork to the building.

Attachment type – Use of attachments to floors, walls, roofs, ceilings, and vibration isolators.

B

Bar joist – Ceiling joists supporting intermediate floors or roof made from steel angles and steel bars.

Base plate – A steel plate used for support and anchorage of an angle support or vibration isolator.

Bed joint – A horizontal seam in a brick or concrete block wall. Also see **Head joint**.

Bolt diameter – Thickness or width of the outside of the threaded portion of the bolt.

Building structure – Steel, concrete, masonry and wood members or surfaces that transfer the weight of the building and equipment to the ground.

Bumpers – Angles or other steel shapes with elastomeric padding rigidly mounted to the building structure in a pattern around the equipment base to limit horizontal movement.

C

Cable brace – A steel cable designed for use as a seismic sway brace for suspended equipment, piping, ductwork, or raceways. Also see **Pre-stretched cable.**

Cant strip – A material used to fill voids in roof flashing.

Cantilevered – A support member connected at one end and unsupported at the other end.

Cast-in-place – A steel shape embedded into concrete.

Cast-in-place anchor – A headed steel bolt set within a concrete form before concrete is poured.

Cold joint – An edge between two concrete surfaces.

Construction documents – Drawings, specifications, and manufacturer's instructions (approved by the appropriate design professional) that define the scope of a project and provide detailed information to seismically restrain the equipment, piping, ductwork, or raceways. Also known as blue prints.

Counter flashing – A light-gauge sheet metal folded support or equipment frame to shed water or snow onto the roof.

Curb – Raised or enclosed framework that supports equipment.

Cure – To gain internal strength over time to withstand external forces.

Cure time – The total time it takes for the material to be at an absolute full load capacity.

D

Design professional - The responsible party, recognized by the authority having jurisdiction, working within their scope of qualifications and providing design services.

Differential movement – The movement between two objects or surfaces.

E

Edge distance – The distance between a concrete anchor and the edge of a concrete surface or concrete cold joint.

Elastomeric – A material with flexibility in all directions that will return to its original shape if removed from its environment.

Elastomeric pad - A resilient natural or synthetic rubber like pad used to reduce sound, shock and high frequency vibrations.

Embedded plate - A steel plate set into concrete to permit a welded attachment.

Embedment – How far a post-installed anchor is inserted into a hole in concrete or wood after the anchor is set in place and torqued.

Embedment depth – See **Embedment**.

Enclosure – A case or housing to protect electrical components.

Equipment – Any mechanical or electrical component.

Expansion anchor – A post-installed anchor that uses some form of wedge or shell held against the edge of a drilled hole with friction.

F

Ferrule – A small metal tube that can be crimped around steel cables.

Fiberglass pad - A pad with a core of resilient fiberglass material covered by a moisture resistent resilient shell used to reduce sound, shock and high frequency vibrations.

Fillet weld – A weld between two pieces of steel where the welded surfaces are at right angles.

Flashing – Metal, asphalt, or elastomeric material with one or more layers surrounding a roof penetration specifically designed to weatherproof the building.

Flexible connector – A connector designed to allow slight movement between a piece of equipment, component, or system and another system in the event of an earthquake.

Flexible mounted equipment – A piece of equipment supported on or from a vibration isolator.

G

Gel time – A specified amount of time for an adhesive to form a jelly-like substance with strength to hold its own weight or the weight of a light steel anchor.

Grommet – A rubber or elastomeric bushing-shaped ring that may be used in restrained springs, snubbers, or with bolts to provide a cushioned or flexible connection.

Groove joint – A mechanical connection between two pipe sections using a tongue-and-groove configuration and elastomeric gasket.

H

Hand tight – The force applied by hand or with hand tools to bring two or more materials firmly in contact without a space.

Head joint – A vertical joint between two concrete blocks in a block wall or two bricks in a brick wall. Also see **Bed joint**.

Headed stud – A large bolt with a threaded shaft and a hexagonal-shaped bolt head typically used for embedment into concrete surfaces or in-filled concrete walls.

Height-saving bracket – A bracket used to accommodate the height of spring isolators without raising the equipment base more than a few inches.

Housed spring – A spring isolator with steel guides usually separated by an elastomeric sheet located on two opposite sides of the spring.

Housed spring isolator - A steel coil spring designed to be loaded in compression along the axis of the spring. Housed springs have a two-piece housing and mounting stud for the purpose of leveling equipment. The housing has limited lateral restraining capabilities and cannot resist uplift.

Housekeeping pad – A concrete pad under equipment that raises the elevation of the equipment above the building structure or structural slab.

I

Inertia base – A heavily weighted base, usually made of concrete, that weighs more than the equipment it supports.

In-filled block – A concrete block wall whose cells are reinforced with rebar and filled with a sand-grout mixture.

Inlet – The location or connection to equipment where a substance such as water or air enters the equipment.

In-line equipment - Equipment connected to ducts or pipes allowing the continuous flow of the medium inside the ducts or pipes.

Isolators – See **Vibration isolators.**

L

Leveling stanchions – See **Stanchions.**

Load path – Seismic support of equipment and internal components that can be traced through connections and support steel to the building structure.

Load transfer angles – Angles bolted to equipment and to the building structure, transferring the weight and earthquake load through the angles to the building structure.

Longitudinal brace – A brace that restrains pipes, ducts, or raceways parallel to the longitudinal direction of the pipe, duct run, or raceway.

M

Moment-resistant - The ability of an object to resist a force that would cause it's rotation or movement around a point or axis.

N

No-hub pipe – Pipe designed for connections that do not interlock or permanently join.

Nominal diameter – The diameter across the outer-most edges of a bolt or threaded rod.

O

Open spring – A spring isolator with a bolt attachment at the top of the spring for connecting to equipment without any horizontal support.

Open spring isolator - A steel coil spring designed to be loaded in compression along the axis of the spring. Open springs have a plate or cup on the bottom and top with a mounting stud.

Outlet – The location or connection to equipment where a substance such as water or air exits the equipment.

Oversized hole - Bolt holes greater than standard bolt holes allowed by industry standards.

P

Pitch pocket - The frame on a roof contouring the sealing material protecting the penetrations or surface-mounted equipment supports on an unprotected building structure.

Plenum – An enclosed space usually made from galvanized sheet steel allowing airflow from one duct system to another; the entrance to and/or exit from a fan or air handling unit.

Plug weld – The weld of a plate or base plate to another metal surface where a plate is perforated with one or more holes, which are then filled with the weld filler material.

Point load – Weight and seismic forces that are focused to a single point connection to the building structure.

Post and beam – An elevated structure usually made from beams resting on posts or stanchions connected to the building structure.

Post-installed anchor – Anchors installed after the concrete has reached its specified strength.

Post-tension (pre-stressed) building – A concrete building structure surface with internal steel cables that are stretched and restrained to permanently compress the concrete surface.

Pre-stressed beam - A concrete beam bonded to steel in tensionin the form of a beam.

Pre-stretched cable – Cable that is stretched after it is manufactured.

R

Rated spring deflection – The dimension a spring will compress when the weight of equipment is applied.

Rehabilitation – A new installation within an existing facility.

Restrained elastomeric mount - An elastomeric mount with an integrated seismic restraining mechanism that limits movement in all horizontal and vertical directions

Restrained spring – A vibration isolator containing a spring enclosed in a welded or bolted steel housing that limits the movement of the spring equipment attachment in all directions.

Restrained spring isolator - A steel coil spring designed to be loaded in compression along the axis of the spring. Restrained springs have a housing with integrated seismic restraining mechanisms, which limit movement in all horizontal and vertical directions.

Rigid-mounted equipment – Equipment solidly braced or bolted directly to the building structure without vibration isolation.

S

Screen – A tube of steel wire mesh used as an adhesive anchor for anchoring to block or brick walls.

Seismic cable – A steel or stainless steel braided rope.

Seismic restraint device – An attachment device designed to restrict movement of equipment during an earthquake.

Seismic restraint device submittals – Documents created by contractors or vendors describing the means and methods for installing seismic restraint devices and submitted for design approval.

Seismic rod clamp – A clamping device for attaching rod stiffeners to a vertical threaded rod.

Seismic separation joint - A space provided between buildings or portions of a building to prevent contact caused by differential movement during an earthquake. For piping, ductwork and conduits crossing the seismic joint, the systems are connected with a flexible component that allows for differential movement at least twice the width of the seismic separation joint.

Self-drilling – A special type of concrete shell anchor with cutting teeth for drilling into concrete.

Self-tapping – Either a sheet metal screw with blades on the end (similar to a drill bit), allowing the screw to drill a hole and embed itself into a steel shape, or a concrete screw with a point and specially designed threads allowing the screw to grip the concrete and embed itself into the concrete.

Set time – The specific time required for material to harden when a light load may be applied.

Shallow concrete anchor – Any anchor with an embedment depth measuring less than 1/8th of its diameter.

Sheet steel housings – Sheet steel that fully or partially encloses a piece of equipment.

Shim – A thin wedge of material used to fill a space.

Snubber – A seismic restraint device used on isolated systems with an air gap and elastomeric bushing or oil-filled hydraulic cylinder (shock absorber) restricting the rapid motion of a pipe.

Snug tight – The force applied by hand or hand tools to bring two or more materials firmly in contact without a space.

Solid brace – A steel angle or strut channel designed for use as a seismic sway brace for suspended equipment, piping, ductwork, or raceways.

Spring-isolated – See **Vibration-isolated.**

Stanchions – Columns or short structural steel shapes placed vertically that connect to equipment bases or horizontal structural steel frames to provide equipment support.

Structural steel shapes – A manufactured steel component in a variety of shapes.

Strut – A manufactured steel shape in various U-shaped patterns and sizes.

Strut frame – Steel framing made from strut members that act as a support to transfer the equipment weight to the building structure. See **Strut**.

Sway brace – Solid braces or cable braces that provide seismic restraint.

T

Tendons – Steel cables used in post-tension buildings. Also see **Post-tension building.**

Thimble – A metal spacer used on a cable to protect it from being bent and damaged.

Transverse brace – A brace that restrains pipes, ducts, or raceways perpendicular to the longitudinal direction.

Toe of the weld – The edge of a fillet weld.

Torque – A turning force around a bolt applied by twisting a bolt head or nut so the components will not separate.

Turn-of-nut method – A process to properly torque a bolt without a special tool like a calibrated torque wrench. See **Hand tight** and **Snug tight**.

V

VAV boxes – A terminal unit or plenum with an internal damper and control actuator that can vary airflow quantities.

Vibration-isolated – Used to describe a system that is separated from the building structure with devices designed to reduce vibration and noise transmission into the building structure.

Vibration isolators – Components containing resilient elements such as steel springs, air springs, molded pre-compressed fiberglass or elastomeric pads used to separate vibrating equipment, piping and ductwork from the building structure.

W

Web – A thin metal strip in a structural steel shape.

Weld base material – The material composition of an item being welded.

WPS - Weld Procedure Specification is required for all welding in accordance with American Welding Society D1.1. The WPS defines the essential variables and their limits for the weld and must be in the vicinity where the weld is occuring.

INDEX

A

acceptable gap 113
actuators 14, 144-147
air separator 14, 99-100
all-directional bracing 19, 27, 30, 32, 36, 39, 63
anchor 156
  adhesive 107, 108-113, 117, 120-122, 149-150
  cast-in-place 107, 114
  concrete bolt 107, 152-153
  concrete screw 107, 117, 118, 122
  drywall 117-124
  embedded plates 107, 131
  externally threaded 151-152
  gap 113
  general 107-113
  internally threaded 154
  lag bolts 107, 115-116, 123
  light-duty fastenings 155-156
  masonry 107, 118-125
  non-adhesive 108
  post-installed 162
  power-actuated 125, 148
  sheet metal screw 117, 123
  shell 107, 108-113
  sleeve 107, 110, 117, 118, 123
  steel bolt 107, 126-130
  through-bolt 117
  toggle bolt 117-118, 122
  umbrella 117, 118
  undercut 107, 108-113
  wedge 107, 110, 117, 118, 123
  welding 131-132
anchor selection guide 148-156
angle 42, 48, 56, 58, 60, 61, 66, 77, 89, 95, 106, 128
attachment types
  duct 16-53
  pipe 54-83
  suspended equipment 84-101
  to building structure 102-106

B

bar joist 104

block walls 118-124

bracing
- all-directional 19, 27, 30, 32, 36, 39, 63
- cable 17-22, 26-27, 29-31, 34-35, 39-40, 57, 62, 63, 67, 85-87, 90-92, 105
- duct, selection 8-9
- in-line duct equipment 10-11
- in-line pipe equipment 14-15
- layout 3-7
- longitudinal 6-7, 17, 23, 27, 29, 34, 61, 62
- non-moment-resistant 24, 38
- pipe, selection 12-13
- steel shaped 20-21, 23-24, 32-33, 36, 37, 88-89, 95-96, 106
- strap 25, 37
- transverse 5-7, 18, 20, 21, 23, 26, 29, 30, 32, 34, 39, 56, 57, 58-59, 60
- trapeze 66-67, 71, 72, 75
- vibration isolation 26-27, 39-40

bracket 78, 114

brick walls 122

brittle valve bodies 15

building structure, attachment to 102-106

bumpers 156

C

cable 134-139
- assemblies 134-139
- bolts with center holes 135
- bracing 17-22, 26-27, 29-31, 34-35, 39-40, 57, 62, 63, 67, 85-87, 90-92, 105
- ferrule clamps 134, 136-137
- wire rope grips 138-139

chase-mounted ducts 47-49

clevis hangers 55-59

coil 10

concrete
- bolt 107
- drilling 109-111

connectors, flexible 140-141
cross bracing 45
curb 44, 45
curing 112

D

dowel
duct bracing
    chase-mounted 47-49
    floor-mounted 8-9, 41-43
    identifying 8
    installation 16-53
    isolated 39
    layout 3-7
    moment-resistant 24, 38
    mounted equipment 10-11
    penetrations 8-9, 50-53
    pre-manufactured 44
    rectangular, suspended 8-9, 16-27
    roof-mounted 8-9, 44-46
    round, suspended 8-9, 28-40
    run 4-7
    seismic, exceptions 3
    selection 8-9
    vibration-isolated 26-27, 39-40
    wall-mounted 8-9, 47-49

E

electronic actuator 14
embedment depth 158
embedded plates 107, 131
equipment
    in-line duct-mounted 10-11
    in-line pipe-mounted 14-15
    suspended, attachment 84-101
expansion joints 142-143

F

fan-coil unit 11
ferrule clamps 134, 136-137
fire damper 10
fire barriers, crossing 9

flashing 51, 158
flexible connectors 140-141
floor-mounted
 ducts 8-9, 41-43
 piping 12-13, 70-72

G

gap, *see acceptable gap*
grouted plate 113

H

heat-exchanger 14, 100-101
hole
 cleaning 111
 clearance 116
 depth 110
 drilling 109-111
humidifier 10

I

in-line
 air separator 99-100
 duct-mounted equipment 10-11
 fan 11
 heat exchanger 100-101
 pipe-mounted equipment 14-15
 pump 97-98
interior penetrations
 duct 8-9, 52-53
 pipe 12-13, 82-83

L

lag bolts 107, 115-116, 117, 123
longitudinal bracing 6-7, 17, 23, 27, 29, 34, 61, 62, 160

M

masonry and drywall anchors *see anchors*
motorized damper 10

N

non-moment-resistant 24, 38

P

penetrations
- duct 8-9, 50-53
- interior 8-9, 12-13, 52-53, 82-83
- pipe 12-13, 79-83
- roof 8-9, 12-13, 50-51, 79-81
- weatherproofing 9, 13

pipe bracing
- double-roller support 68
- floor-mounted 70-72
- identifying 12
- installation 54-83
- isolated 65, 81
- layout 3-7
- moment-resistant
- offset 4
- penetrations 70-83
- pre-manufactured 78
- mounted equipment 14-15
- roof-mounted 73-75
- runs 4-7
- seismic, exceptions 3
- selection 12-13
- suspended 54-69
- transverse bracing 5
- vibration-isolated 65
- wall-mounted 76-78

pipe clamps 60-62

pitch pocket 45

R

rod
- hangers 58, 60, 61, 62, 63
- stiffeners 86
- threaded 129
- vertical 17, 18, 19, 20, 26, 27, 29, 30, 32, 39

roof-mounted
- duct 8-9, 44-46
- pipe 12-13, 73-75

roof penetrations
duct 8-9, 50-51
pipe 12-13, 79-81
weatherproofing 9, 13

S

screen insert 121
silencer 11
seismic
bracing exceptions 3
joints 140-143
separations, crossing 9
sheet steel 162
special cases
cables 134-139
seismic joints 140-143
valve and valve actuators 144-147
stanchion 163
steel bolt connections 126-130
steel shaped bracing 20-21, 23-24, 32-33, 36, 37, 88-89, 95-96, 106
strap support 25, 37
strut 43, 56, 58, 60, 61, 66, 71, 77, 89, 106
suspended attachments
anchor sizes for 133
ducts 16-40
equipment 84-101
piping 54-69
rectangular ducts 16-27
round ducts 28-40

T

thimble 136-137
threaded rods
attaching top connections 129
transverse bracing 5-7, 18, 20, 21, 23, 26, 29, 30, 32, 34, 39, 56, 57, 58-59, 60
locating 5
spacing limitations 5
trapeze support 66-67, 71, 72, 75
turn-of-nut method 127

V

valves 14, 144-147
valve actuator 14, 144-147
VAV terminal 11
vertical supports 4
vibration isolation 26-27, 39-40

W

wall-mounted attachment
    duct 8-9, 47-49
    pipe 12-13, 76-77
webs 164
welding 131-132
wire rope grips 138-139
wood
    blocking support 74
    beam construction 103

FEMA

FEMA P-414
Catalog No. 10148-1

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LIMITED ASBESTOS SURVEY REPORT

Fort Lauderdale/Hollywood International Airport
Air Traffic Control Tower & Base Building
4150 Southwest 12th Terrace
Fort Lauderdale, Florida 33315

GLE Project No.: 18000-19284

Prepared for:

Federal Aviation Administration
1701 Columbia Avenue
College Park, Georgia 30337

April 2018

Prepared by:

1000 NW 65th Street, Suite 300-D
Ft. Lauderdale, Florida 33309
754-223-2697 • Fax 754-223-2937

ARCHITECTS | ENGINEERS | ENVIRONMENTAL CONSULTANTS

May 2, 2018

Ms. Sushma Patel
Federal Aviation Administration
1701 Columbia Avenue
College Park, Georgia 30337

RE: Limited Asbestos Survey Report
FLL Air Traffic Control Tower & Base Building
4150 Southwest 12th Terrace
Fort Lauderdale, Florida 33315

GLE Project No.: 18000-19284

Dear Ms. Patel:

GLE Associates, Inc. (GLE) performed a Limited survey for Asbestos-Containing Materials (ACMs) on April 17, 2018, at the FLL Air Traffic Control Tower & Base Building located at 4150 Southwest 12th Terrace, in Fort Lauderdale, Florida. The survey was performed by Mr. Brandon Christensen with GLE. This report outlines the sampling and testing procedures, and presents the results along with our conclusions and recommendations.

GLE appreciates the opportunity to serve as your consultant on this project. If you should have any questions, or if we can be of further service, please do not hesitate to call.

Sincerely,
GLE Associates, Inc.

Brandon Christensen
Project Manager

Robert B. Greene, PE, PG, CIH, LEED AP
President
Florida LAC # EA 0000009

BSC/MBC/RBG/el

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TABLE OF CONTENTS

1.0 INTRODUCTION **1**
1.1 Introduction 1
1.2 Facility Description 1

2.0 RESULTS **1**
2.1 Asbestos Survey Procedures 1
2.2 Identified Suspect Asbestos-Containing Materials 2
Table 2.2-1: Summary of Homogeneous Sampling Areas 3

3.0 CONCLUSIONS AND RECOMMENDATIONS **4**
3.1 General 4

4.0 LIMITATIONS AND CONDITIONS **4**

APPENDICES
Appendix A – Analytical Results and Chain of Custody
Appendix B – Personnel and Laboratory Certifications

1.0 INTRODUCTION

1.1 INTRODUCTION

The purpose of this limited survey was to identify accessible ACMs and their general locations within the FLL Air Traffic Control Tower (ATCT) and base building, located at 4150 southwest 12th terrace, located in Fort Lauderdale, Florida. The survey was limited to the building materials that could be impacted during the ATCT roof and catwalk renovations. The survey was conducted pursuant to National Emission Standards for Hazardous Air Pollutants (NESHAP, 40 CFR 61) requirements, associated with the scheduled renovation plans. The survey was performed on April 17, 2017, by Mr. Brandon Christensen, an Environmental Protection Agency/Asbestos Hazard Emergency Response Act (EPA/AHERA) accredited inspector. The scope of this survey did not include demolition of any building components, evaluation of architectural plans, or the quantification of materials for abatement purposes, or removal cost estimating.

1.2 FACILITY DESCRIPTION

A summary of the facility investigated is outlined in the table below.

Facility Type:	Government
Construction Date:	Unknown
Number of Floors:	10
Structural	
Foundation:	Concrete Slab
Wall Support:	Concrete Masonry Unit
Exterior Finish:	Stucco, Paint
Roof Support:	Metal Truss,
Roof System Type:	Built up Roof, PVC, Rolled Asphalt Roof
Mechanical/Plumbing	**Not in Scope**
Interior	**Not in Scope**

2.0 RESULTS

2.1 ASBESTOS SURVEY PROCEDURES

The survey was performed by visually observing accessible areas of the subject area. EPA/AHERA accredited inspectors performed the visual observations (refer to Appendix B for personnel qualifications).

After the overall visual survey was completed, representative sampling areas were determined. The surveyors delineated homogeneous areas of suspect materials and samples of each material were obtained, in general accordance with regulations as established by the Occupational Safety and Health Administration (OSHA) and NESHAP. The field surveyors determined sample locations based on previous experience. Both friable and non-friable materials were sampled. A friable material is one that can be crushed when dry by normal hand pressure. This survey did not include the demolition of building components to access suspect material.

After completion of the fieldwork, the samples were delivered to GLE's National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory for analysis. The samples were analyzed by Polarized Light Microscopy (PLM) coupled with dispersion staining, in general accordance with EPA-600/R-93/116. Utilizing this procedure, the various asbestos minerals (chrysotile, amosite, crocidolite, actinolite, tremolite, and anthophyllite) can be determined. The percentages of asbestos minerals in the samples were visually determined by the microscopist. Please note that the EPA designates all materials containing greater than 1% asbestos as an "asbestos-containing material" (ACM).

Regulated Asbestos-Containing Material (RACM) is defined as (a) Friable asbestos materials, (b) Category I non-friable ACM that has become friable, (c) Category I non-friable ACM that will be or has been subjected to sanding, grinding, cutting, or abrading, or (d) Category II non-friable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder by the forces expected to act on the material in the course of demolition or renovation operations regulated by this subpart.

Category I and Category II non-friable ACM, as defined by the EPA:

- Category I non-friable ACM means asbestos containing packings, gaskets, resilient floor covering, asphalt roofing products, and pliable sealants and mastics that are in good condition and not friable, containing more than 1% asbestos, as determined using the method specified in Appendix E, Subpart E, 40 CFR Part 763, Section 1, PLM.

- Category II non-friable ACM means any material, excluding Category I non-friable ACM, containing more than 1% asbestos as determined using the methods specified in Appendix E, Subpart E, 40 CFR Part 763 Section 1, PLM that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.

2.2 IDENTIFIED SUSPECT ASBESTOS-CONTAINING MATERIALS

A total of thirty-three samples of suspect building materials were collected from the subject area during the survey, representing eleven different homogeneous areas. The results of the laboratory analyses are included in Appendix A.

A summary of the homogenous sampling areas of suspect ACM determined to be present is outlined in the following table.

TABLE 2.2-1: SUMMARY OF HOMOGENEOUS SAMPLING AREAS FLL ATCT AND BASE BUILDING 4150 SOUTHWEST 12TH TERRACE FORT LAUDERDALE, FLORIDA 33315							
HA #	**HOMOGENEOUS MATERIAL DESCRIPTION**	**HOMOGENEOUS MATERIAL LOCATION**	**FRIABILITY (F /NF)**	**% ASBESTOS***	**# OF SAMPLES COLLECTED**	**APPROXIMATE QUANTITY**	**ACM CATEGORY**
M-01	White Coating w/ Black Pitch Pan Flashing	ATCT Roof	NF	ND	3	NIS	NA
M-02	White Caulking at Antenna	ATCT Roof Parapet Wall	NF	ND	3	NIS	NA
M-03	White PVC Roof Membrane w/ Yellow Adhesive	ASDE Penthouse Roof	NF	ND	3	NIS	NA
M-04	White Roof Caulking	ASDE Penthouse Roof	NF	ND	3	NIS	NA
M-05	Black Caulking at Catwalk Parapet Wall	Catwalk Parapet Wall	NF	ND	3	NIS	NA
M-06	Gray w/ Black Pitch Pan Flashing	ATCT Roof	NF	ND	3	NIS	NA
R-01	Black Rolled Roof Curb	ATCT Roof	NF	ND	3	NIS	NA
R-02	Black Rolled Roof	Base Building Roof	NF	ND	3	NIS	NA
RBU-01	White Coating over Built Up Roof	ATCT Roof	NF	ND	3	NIS	NA
RF-01	Black Roof Edge Flashing	Base Building Roof	NF	ND	3	NIS	NA
RF-02	Black Roof Vent Flashing	Base Building Roof	NF	ND	3	NIS	NA

ASBESTOS CONTENT Expressed as percent	* = The facility owner has the option of point-counting by polarized light microscopy (PLM) those RACM whose asbestos content is less than 10% in order to more accurately determine the asbestos content therein.				
	PC = Results based on Point-Count analysis				
FRIABILITY	F = Friable Material	NF = Non-Friable Material			
ACM CATEGORY	RACM = Regulated ACM	CAT I = Category I non-friable ACM	CAT II = Category II non-friable ACM		
ABBREVIATIONS:	NA = Not Applicable	ND = None Detected	NIS = Not in Scope	C = Chrysotile	A = Amosite
	HA = Homogeneous Area	SF = Square Feet	LF = Linear Feet	CF = Cubic Feet	AP = Assumed Positive

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 GENERAL

No asbestos-containing materials were identified in the scope of this survey.

4.0 LIMITATIONS AND CONDITIONS

As a result of previous renovations, there may be hidden materials, such as floor tile, sheet vinyl flooring, insulation, etc. These materials may be found in various areas hidden under existing flooring materials or in wall cavities. Any materials found during construction activities, either not addressed in this survey report, or similar to the ACM identified in this survey report should be assumed to be ACM until sampling and analysis documents otherwise.

Because of the hidden nature of many building components (i.e. within mechanical chases), it may be impossible to determine if all of the suspect building materials have been located and subsequently tested. Destructive testing in some instances is not a viable option. We cannot, therefore, guarantee that all potential ACM has been located. For the same reasons, estimates of quantities and/or conditions are subject to readily apparent situations, and our findings reflect this condition. We do warrant, however, that the investigations and methodology reflect our best efforts based upon the prevailing standard of care in the environmental industry.

The information contained in this report was prepared based upon specific parameters and regulations in force at the time of this report. The information herein is only for the specific use of the client and GLE. GLE accepts no responsibility for the use, interpretation, or reliance by other parties on the information contained herein, unless prior written authorization has been obtained from GLE.

APPENDIX A
Analytical Results and Chain of Custody

SUMMARY OF BULK SAMPLE ANALYSIS

FAA-Engineering Services; FLL ATCT & Base Building

18000-19284

Sample	Sample Type	Fiber Type	
M-01A	White Coating & Black Pitch Pan Flashing	100%	Polymer, Quartz, Calcite, Clay, Mica
M-01B	White Coating & Black Pitch Pan Flashing	100%	Polymer, Quartz, Calcite, Clay, Mica
M-01C-QC	White Coating & Black Pitch Pan Flashing	100%	Polymer, Quartz, Calcite, Clay, Mica
M-02A	White Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-02B	White Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-02C	White Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-03A	White PVC Roof Membrane & Yellow Adhesive	100%	Polymer, Quartz, Calcite, Clay, Mica
M-03B	White PVC Roof Membrane & Yellow Adhesive	100%	Polymer, Quartz, Calcite, Clay, Mica
M-03C	White PVC Roof Membrane & Yellow Adhesive	100%	Polymer, Quartz, Calcite, Clay, Mica
M-04A	White Roof Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-04B	White Roof Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-04C	White Roof Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica

Analyst / Approved Signatory:

Darryl Neldner

* Polarized Light Microscopy coupled with dispersion is the technique used for identification in accordance with EPA 600/M4-82-020, EPA 600/R-93/116, and NIOSH Method 9002.

** The percentage of each component is visually estimated. The result of this analysis relate only to the material tested.
The report shall not be used to claim product endorsement by NVLAP or any agency of the U.S. Government.
(>1% greater than one percent, <1% less than one percent) QC - Sample reanalyzed for QA/QC.

Analysis performed by GLE Associates, Inc. NVLAP Code 102003-0, CO AL-17485, TX 30-0337

Feedback regarding laboratory performance should be addressed to lab@gleassociates.com.

SUMMARY OF BULK SAMPLE ANALYSIS

FAA-Engineering Services; FLL ATCT & Base Building

18000-19284

Sample	Sample Type		Fiber Type
M-05A-QC	Black Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-05B	Black Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-05C	Black Caulk	100%	Polymer, Quartz, Calcite, Clay, Mica
M-06A	Gray/Black Pitch Pan Flashing	100%	Bitumen, Quartz, Calcite, Mica
M-06B	Gray/Black Pitch Pan Flashing	100%	Bitumen, Quartz, Calcite, Mica
M-06C	Gray/Black Pitch Pan Flashing	100%	Bitumen, Quartz, Calcite, Mica
R-01A	Black Rolled Roof Curb	100%	Bitumen, Quartz, Calcite, Mica
R-01B	Black Rolled Roof Curb	100%	Bitumen, Quartz, Calcite, Mica
R-01C	Black Rolled Roof Curb	100%	Bitumen, Quartz, Calcite, Mica
R-02A	Black Rolled Roof	100%	Bitumen, Quartz, Calcite, Mica
R-02B-QC	Black Rolled Roof	100%	Bitumen, Quartz, Calcite, Mica
R-02C	Black Rolled Roof	100%	Bitumen, Quartz, Calcite, Mica
RBU-01A	White Coating	100%	Polymer, Quartz, Calcite, Clay, Mica
RBU-01B	White Coating	100%	Polymer, Quartz, Calcite, Clay, Mica
RBU-01C	White Coating	100%	Polymer, Quartz, Calcite, Clay, Mica

Analyst / Approved Signatory:

Darryl Neldner

* Polarized Light Microscopy coupled with dispersion is the technique used for identification in accordance with EPA 600/M4-82-020, EPA 600/R-93/116, and NIOSH Method 9002.

** The percentage of each component is visually estimated. The result of this analysis relate only to the material tested.
The report shall not be used to claim product endorsement by NVLAP or any agency of the U.S. Government.
(>1% greater than one percent, <1% less than one percent) QC - Sample reanalyzed for QA/QC.

*** This report shall not be reproduced except in full, without the written approval of the laboratory. GLE Report # 22502

Analysis performed by GLE Associates, Inc. NVLAP Code 102003-0, CO AL-17485, TX 30-0337

Feedback regarding laboratory performance should be addressed to lab@gleassociates.com.

SUMMARY OF BULK SAMPLE ANALYSIS

FAA-Engineering Services; FLL ATCT & Base Building

18000-19284

Sample	Sample Type		Fiber Type
RF-01A	Black Roof Edge Flashing	100%	Bitumen, Quartz, Calcite, Mica
RF-01B	Black Roof Edge Flashing	100%	Bitumen, Quartz, Calcite, Mica
RF-01C	Black Roof Edge Flashing	100%	Bitumen, Quartz, Calcite, Mica
RF-02A	Black Roof Vent Flashing	100%	Bitumen, Quartz, Calcite, Mica
RF-02B	Black Roof Vent Flashing	100%	Bitumen, Quartz, Calcite, Mica
RF-02C-QC	Black Roof Vent Flashing	100%	Bitumen, Quartz, Calcite, Mica

Analyst / Approved Signatory:

Darryl Neldner

* Polarized Light Microscopy coupled with dispersion is the technique used for identification in accordance with EPA 600/M4-82-020, EPA 600/R-93/116, and NIOSH Method 9002.

** The percentage of each component is visually estimated. The result of this analysis relate only to the material tested.
The report shall not be used to claim product endorsement by NVLAP or any agency of the U.S. Government.
(>1% greater than one percent, <1% less than one percent) QC - Sample reanalyzed for QA/QC.

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Analysis performed by GLE Associates, Inc. NVLAP Code 102003-0, CO AL-17485, TX 30-0337

Feedback regarding laboratory performance should be addressed to lab@gleassociates.com.

CHAIN OF CUSTODY/SAMPLE TRANSMITTAL FORM

GLE Associates, Inc.
1000 NW 65th Street, Suite 300-D
Ft. Lauderdale, FL 33309
PHONE: (954) 968-6414 FAX: (954) 968-6090

CLIENT:	FAA – Engineering Services	LAB 22502
PROJECT #:	18000-19284	
PROJECT:	FLL ATCT and Base Building	
LABORATORY SENT TO:	GLE	
DATE:	4/17/2018	

SAMPLE INFORMATION

SAMPLE #	DESCRIPTION	SAMPLE #	DESCRIPTION
M-01 ABC	White Coating w/ Black Pitch Pan Flashing	R-01 ABC	Black Rolled Roof Curb
M-02 ABC	White Caulk at Antenna	R-02 ABC	Black Rolled Roof
M-03 ABC	White PVC Roof Membrane w/ Yellow Adhesive	RBU-01 ABC	White Coating over Built Up Roof
M-04 ABC	White Roof Caulking	RF-01 ABC	Black Roof Edge Flashing
M-05 ABC	Black Caulking at Catwalk Parapet Wall	RF-02 ABC	Black Roof Vent Flashing
M-06 ABC	Gray w/ Black Pitch Pan Flashing		

IMPORTANT: TOTAL NUMBER OF SAMPLES SUBMITTED	**33**
IMPORTANT: POSITIVE STOP ANALYSIS	Yes
IMPORTANT: E-MAIL RESULTS TO	Jsimmons/elongo

NOTE:

Turnaround time starts at receipt by lab and does not include weekend or holidays.

Select Turnaround Time

☐ 3 hour ☐ 6 Hour ☐ 24 Hour ☐ 48 Hour ☐ 3 Day ☒ 4 Day

REPORT RESULTS TO THE ADDRESS ABOVE

CHAIN OF CUSTODY: GLE ASSOCIATES, INC.	CHAIN OF CUSTODY: LABORATORY
PACKAGED BY: Brandon Christensen	SAMPLES RECEIVED BY:
DATE PACKAGED: 4/17/2018	DATE: 4.18.18
METHOD OF TRANSMITTAL: FEDEX	TIME:
TRANSMITTED BY: ELongo	CONDITION OF PACKAGED SAMPLES:

CHAIN OF CUSTODY: RETURNED TO GLE ASSOCIATES, INC.

RECEIVED BY:	DATE:
INVENTORIED BY:	DATE:
REPACKAGED AND SEALED BY:	DATE:

PAGE: OF

APPENDIX B
Personnel and Laboratory Certifications

RICK SCOTT, GOVERNOR

JONATHAN ZACHEM, SECRETARY

Florida dbpr

STATE OF FLORIDA
DEPARTMENT OF BUSINESS AND PROFESSIONAL REGULATION

ASBESTOS LICENSING UNIT

THE ASBESTOS BUSINESS ORGANIZATION HEREIN IS LICENSED UNDER THE PROVISIONS OF CHAPTER 469, FLORIDA STATUTES

GLE ASSOCIATES INC

ROBERT BLAIR GREENE
5405 CYPRESS CENTER DRIVE
SUITE 110
TAMPA FL 33609

LICENSE NUMBER: ZA0000034

EXPIRATION DATE: NOVEMBER 30, 2019

Always verify licenses online at MyFloridaLicense.com

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STATE OF FLORIDA
DEPARTMENT OF BUSINESS AND PROFESSIONAL REGULATION

ASBESTOS LICENSING UNIT
2601 BLAIR STONE ROAD
TALLAHASSEE FL 32399-0783

(850) 487-1395

GREENE, ROBERT BLAIR
GLE ASSOCIATES INC
5405 CYPRESS CENTER DR
SUITE 110
TAMPA FL 33609

Congratulations! With this license you become one of the nearly one million Floridians licensed by the Department of Business and Professional Regulation. Our professionals and businesses range from architects to yacht brokers, from boxers to barbeque restaurants, and they keep Florida's economy strong.

Every day we work to improve the way we do business in order to serve you better. For information about our services, please log onto **www.myfloridalicense.com**. There you can find more information about our divisions and the regulations that impact you, subscribe to department newsletters and learn more about the Department's initiatives.

Our mission at the Department is: License Efficiently, Regulate Fairly. We constantly strive to serve you better so that you can serve your customers. Thank you for doing business in Florida, and congratulations on your new license!

STATE OF FLORIDA
DEPARTMENT OF BUSINESS AND PROFESSIONAL REGULATION

EA0000009 ISSUED: 11/15/2016

ASBESTOS CONSULTANT - ENGINEER
GREENE, ROBERT BLAIR
GLE ASSOCIATES INC

IS LICENSED under the provisions of Ch.469 FS.
Expiration date : NOV 30, 2018 L1611150002176

DETACH HERE

RICK SCOTT, GOVERNOR KEN LAWSON, SECRETARY

STATE OF FLORIDA
DEPARTMENT OF BUSINESS AND PROFESSIONAL REGULATION
ASBESTOS LICENSING UNIT

LICENSE NUMBER	
EA0000009	

The ASBESTOS CONSULTANT - ENGINEER
Named below IS LICENSED
Under the provisions of Chapter 469 FS.
Expiration date: NOV 30, 2018

GREENE, ROBERT BLAIR
GLE ASSOCIATES INC
5405 CYPRESS CENTER DR
SUITE 110
TAMPA FL 33609

ISSUED: 11/15/2016 DISPLAY AS REQUIRED BY LAW SEQ # L1611150002176

Asbestos Consulting & Training Systems

41489.6125CERT/BIR

900 N.W. 5TH Avenue, Fort Lauderdale, Florida 33311 (954) 524-7208

Processed By:

Seagull

To Authenticate Certificate
www.seagulltraining.com
1-800-966-9933

This is to Certify that

Brandon Christensen

XXX-XX-4647

9110-D SW 20 ST, Davie, FL 33324

has successfully completed an English

Asbestos Building Inspection Refresher

28-Jul-17 TO 28-Jul-17

UNDER CIVIL AND CRIMINAL PE[illegible] OF LA[illegible] MAKING OR SU[illegible]N OF FALSE OR [illegible]LENT S[illegible]NTS OR [illegible]RESE[illegible]NS (18 U.S.C. 1[illegible] AND 15 U.[illegible]S), I CERTIFIY [illegible]IS TRAINING CO[illegible] WITH AL[illegible] [illegible]EQUIR[illegible]S OF TITLE IV OF [illegible] TOXIC SUB[illegible]CONTROL [illegible]FR PART 745 OR [illegible] AND/ANY OT[illegible]CABLE F[illegible] STATE, OR LO[illegible]QUIREMENTS, [illegible]

Meets state requirements of FL49-0001020/CN-0006273 and UT (6.0 core).

NDAAC Provider #451 Trainer(s): Mark Knick

TEST SCORE: 84 % Training Address: 900 NW 5th Ave, Fort Lauderdale, FL 33311

Successful course completion based on exam score on: 07/28/17

James F. Stump, Course Sponsor

Certificate Number: 172856

This Certificate Expires:

28-Jul-18 07/28/18

Course Number: SE1730

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 102003-0

GLE Associates, Inc.
Tampa, FL

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Asbestos Fiber Analysis

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

DEPARTMENT OF COMMERCE • UNITED STATES OF AMERICA

2018-04-01 through 2019-03-31
Effective Dates

For the National Voluntary Laboratory Accreditation Program

NVLAP® National Voluntary Laboratory Accreditation Program

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

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Email: dneldner@gleassociates.com
http://www.gleassociates.com

ASBESTOS FIBER ANALYSIS — NVLAP LAB CODE 102003-0

Bulk Asbestos Analysis

Code	Description
18/A01	EPA -- 40 CFR Appendix E to Subpart E of Part 763, Interim Method of the Determination of Asbestos in Bulk Insulation Samples
18/A03	EPA 600/R-93/116: Method for the Determination of Asbestos in Bulk Building Materials

For the National Voluntary Laboratory Accreditation Program

Effective 2018-04-01 through 2019-03-31

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