NATIONAL RENEWABLE ENERGY LABORATORY

CONSTRUCTION SPECIFICATIONS

FOR

FLATIRONS CAMPUS
BUILDING 251 RECONFIGURATION

Prepared By:

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ISSUED FOR 90% SET

SPECIFICATIONS
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SECTION 010000
GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. The General Conditions, Supplementary Conditions, Division I –General Requirements, the Drawings and Specifications and any subsequent Addenda and modifications to the contract are a part of every section of the technical sections (Divisions 2 through 33) of the specifications and have the same force as if they were entirely repeated in every technical section of the specifications.
2. Specifications are abbreviated, simplified or streamlined and include incomplete sentences. Omissions of words or phrases are intentional. Supply omitted words or phrases by inference.
3. Work, which is not fully specified and/or detailed, shall comply with all applicable recognized standards of the construction industry.
4. If discrepancies exist between the Specifications and the Drawings, Contractor shall inform Owner in order that a clarification can be made. The Specifications shall take precedence over the Drawings unless otherwise indicated.

B. Related Sections

1. All specifications from Division 1 through Division 33.

1.2 REFERENCES

A. All work shall comply with all applicable laws, codes and regulations in effect at the time of issuance of the drawings and specifications.

B. The most recent contract documents, shop drawings, and other instructions shall be used. Contractor is responsible for distribution to all subcontractors and other applicable parties.

1.3 DEFINITONS

A. Provide: Supply, pay for, store as required and install.

1.4 SUBMITTALS

A. See Section 013000.

1.5 QUALITY ASSURANCE

A. All material shall comply with the following standards:

1. Industry codes and standards for engineering and construction.

B. Do not scale drawings. Field verify existing conditions.

1.6 DELIVERY, STORAGE, AND PROTECTION

A. Owner will provide for the security of their own operations from vandalism, theft burglary and robbery until the project is completed.

B. Contractor shall be responsible for the security of their own operations from vandalism, theft, burglary and robbery until the project is completed.

1.7 PROJECT/SITE CONDITIONS

A. Access to the project is limited to persons performing the work, to Owner and his agents, to Architect and his agents and to governmental authorities having jurisdiction. Confine operations

under this contract to the portion of the Owners property within the contract limits and designated access routes unless specific approval otherwise has been obtained by the Owner.

B. Contractor and sub-contractors shall comply with Owner's security requirements.

C. Unauthorized persons are not allowed access to contract documents or Owner's property.

1.8 SEQUENCING AND SCHEDULING

A. All disruptions or interference with Owner's operations (including Owner's security operations) shall be minimized. A disruption is defined as any one or a combination of any of the following:

1. Excessive noise
2. Excessive dust
3. Excessive vibration
4. Offensive odors
5. Offensive behavior
6. Deprivation of normal conveniences
7. Apparent threat to safety

B. If certain disruptions are unavoidable for execution of the work, consult with the Owner. Do not proceed with such a disruption until mutual agreement has been reached regarding timing, intent of disruption and any other considerations.

1.9 WARRANTY

A. A one-year warranty is required on all work starting at Beneficial Occupancy.

PART 2 - PRODUCTS (NOT USED)

2.1 MANUFACTURERS

A. Approved manufacturers will be identified in each section where required.

B. Contractor may substitute other equal products upon Owner's approval unless the project specifically states that no substitutions are allowed.

2.2 MATERIALS

A. Any salvable items as indicated on the drawings shall be removed and stored as directed by the Owner

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 011000
SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Work under this contract includes all materials, equipment and labor necessary to complete the work indicated on the drawings, described in specifications or reasonably inferred.
2. Contractor shall make a complete examination of the drawings, documents and specifications, and shall make his own determination that the set is complete. Upon discovery of omissions or discrepancies, the contractor shall report these to the Owner.
3. Contractor shall be liable for errors and/or corrections made necessary by the use of out of date drawings or project documents.

1.2 QUALITY ASSURANCE

A. All workmanship and materials shall comply with industry standards.

1.3 DELIVERY, STORAGE, AND PROTECTION

A. Contractor shall limit use of premises to work and storage of particular materials and products for contracted work.

B. Coordinate use of premises under direction of Owner.

C. Assume full responsibility for the protection and safekeeping of products under this contract stored on the site.

D. Move any stored products, under contractor's control, which interfere with operation of the owner or separate contractor.

E. Provide protection against rain, snow, wind, ice, storms, or heat so as to maintain work, materials, apparatus, and fixtures free from injury or damage. At the end of each day's work, cover new work likely to be damaged.

F. Provide and maintain adequate protection of work from damage due to freezing, especially freezing earth and soil. Risk of proceeding with the work on or with freezing or frozen materials will be the sole responsibility of the Contractor.

G. Provide protection from damage at all times from rainwater, ground water, backing up of drains or sewers, and other water. Provide pumps and equipment enclosures to provide this protection.

1.4 PROJECT/SITE CONDITIONS

A. Contractor shall at all times conduct operations as to insure the least inconvenience to the employees of NREL and the general public.

B. Contractor shall provide NREL the maximum amount of notice possible for utility interruptions. A minimum of 72 hours notice is required for any utility interruption.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

A. Replacement and rerouting of existing ductwork mains to improve system performance.

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B. Replace existing VAV and fan-powered terminal units with new single duct VAV units with hydronic reheat coils.

C. Replace existing pneumatic controls to terminal units and other equipment with new connections to existing Delta digital control system.

D. Replace existing lighting controls system including existing fluorescent and non-LED light fixtures with new LED fixtures.

E. Remove movable partitions in NW office space and provide new hard-walled offices.

F. Replace existing grid ceiling tiles.

~~PART 3~~

END OF SECTION

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SECTION 013100
PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. General Contractor is responsible for all work of this contract. General Contractor shall:
   a. Assign and subcontract portions of work as required to assure all work is constructed in compliance with contract documents.
   b. Coordinate work of the separate contractors for the project.
   c. Coordinate work of the contract with work by separate contractors.
   d. Comply with orders and instructions of Owner.
2. Subcontractors shall:
   a. Coordinate work of own employees and subcontractors.
   b. Expedite work to assure compliance with schedules.
   c. Coordinate work with that of other subcontractors and work by separate contractors.
   d. Comply with orders and instructions of Owner.

1.2 QUALITY ASSURANCE

A. All work will be performed in compliance with all applicable local, state and federal environmental, safety, and health regulations (e.g. OSHA, EPA, DOE, Colorado Department of Health, etc.).

B. The Contractor shall submit a formal written safety plan for approval prior to the start of work. The Contractors safety plan shall include an activity hazard analysis. This analysis shall identify potential hazardous activities and the controls to be implemented to reduce the hazards.

C. The Contractor shall be responsible for the activities of all Subcontractors on the project, relative to environmental, safety, health and security issues, and shall ensure that all Contractor and Subcontractor employees are trained in the safety and security issues addressed in the above referenced orientation.

D. The contractor shall designate an employee who is knowledgeable in ES&H construction requirements as the contractor safety officer. The contractor safety officer is responsible for ensuring compliance with applicable OSHA, NREL and ES&H requirements.

E. The contractor shall report to the NREL construction project manager within ~~two~~ one hour~~s~~ any employee injury/illness requiring medical attention in excess of first aid, or incidents that result in damages to equipment or facilities.

F. The contractor shall provide to the NREL construction project manager quarterly summaries of occupational injury/illness.

G. The contractor shall suspend operations and/or notify the NREL construction project manager if unanticipitated conditions are encountered that present a possible ES&H exposure.

H. The contractor shall post on the project construction sign the following:

1. Emergency telephone numbers
2. The contractors safety plan or a location where it may be accessed
3. The NREL construction Safe Work Permit

4. DOE ES&H poster; form DOE F-5480.2
5. OSHA summary of occupational injury/illness
~~6. Storm water discharge permit notice, if applicable~~

I. The contractor shall ensure that appropriate work practices and engineering controls are applied to protect the health of contractor, visitors and NREL employees, DOE property and the environment.

J. The contractor shall furnish necessary personnel protective equipment to employees when engineering controls are not feasible or adequate; ensuring that necessary training is provided for use of the equipment; and that the equipment is appropriate, properly used and maintained.

K. The contractor shall report immediately to the NREL construction project manager any release of material that may affect environmental quality or life.

L. The contractor shall collect, store and dispose of all construction waste in accordance with applicable laws and regulations. Waste streams that are hazardous or otherwise regulated shall be reported to the NREL construction project manager before the waste is generated, and disposal shall be coordinated with the NREL ES&H Office. The contractor may be required to submit a waste management plan to the NREL project manager for approval by the NREL ES&H Office before generating these wastes.

M. The contractor shall ensure the installation of storage tanks be performed in accordance with NREL's *Above Ground Storage Tank Management Program*.

N. The contractor shall implement necessary corrective actions for deficiencies reported by DOE, the NREL construction project manager or other authority having jurisdiction.

~~O. The contractor shall implement erosion controls in accordance with the *Storm Water Pollution Prevention Plan*.~~

~~P.~~O. The contractor shall stabilize and revegatate the site in accordance with project specifications.

1.3 PROJECT/SITE CONDITIONS

A. The Contractor shall coordinate work of the various sections of the specifications.

B. The Contractor shall verify characteristics of elements of interrelated operating equipment are compatible; coordinate work of various sections which have interdependent responsibilities for installing, connecting to, and placing in service, such equipment.

C. The Contractor shall coordinate space requirements and installation of mechanical and electrical work that are indicated diagrammatically on drawings. Follow routing shown for pipes, ducts, and conduits, as closely as practical; make runs parallel with lines of building. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

D. In finished areas (except as otherwise shown) the subcontractor shall conceal pipes, ducts, and wiring in the construction. Coordinate locations of fixtures and outlets with finish elements.

1.4 WARRANTY

A. Warranty period for services, products and equipment will begin at Beneficial Occupancy unless otherwise agreed upon.

1.5 PREPARATION

A. Orientation Meeting

1. Contractor is required to attend an orientation meeting to be held at NREL where safety and security procedures will be provided and discussed prior to work on NREL sites. A NREL Work

Entry Clearance Form, a Safe Work Permit, Excavation Permit, Hot Work Permit for soldering, welding, plasma cutting and any torch type work, and other permits will be reviewed, discussed, and issued as required. Security matters and work schedules will be addressed at this orientation meeting.

2. Prior to the orientation meeting, the Contractor shall identify any potentially hazardous activities (e.g. welding/cutting, use of hazardous materials, crane operations, trenching, utility interruptions, etc.) to be conducted as part of the project and the controls that will be implemented to reduce the hazards to an acceptable level. The nature of research activities that NREL may be conducting in the vicinity of the construction project must be considered when determining what construction activities are hazardous.

3. The Contractor shall submit a list of any and all hazardous materials to be used during the project, a Material Safety Data Sheet (MSDS) for each hazardous material on the list, and controls to be implemented during the storage, use, and disposal of these materials. Hazardous materials may include, but are not limited to, paints, thinners, solvents, adhesives, mastics, caulking compounds, cleaning agents, and certain structural materials. NREL will review and accept the contractor safety plan, hazardous activities, hazardous materials, and proposed controls before any construction activities may begin. In addition, the contractor shall submit, upon request, information on the construction contractor's hazard communication program.

4. All Contractor and Subcontractor employees are to wear NREL identification badges on their outer garment, upper portion of their body, at all times while on NREL premises. Arrangements for badges will be accomplished at the scheduled orientation meeting. All issued badges must be surrendered immediately to the Security Office upon termination of activities at the Laboratory.

B. Contractor shall:

1. Establish project procedures for communications.

   a. Contractor must designate an on-site person in-charge when any Contractor personnel are on site. This person-in-charge is responsible to advise the Project Manager whenever Contractor personnel are at NREL work sites. If after-hours work is anticipated, the Contractor must inform the Project Manager and Security so proper clearances can be obtained.

   b. The single point of contact for technical matters on this subcontract is the NREL Project Manager. The Contractor is responsible to coordinate all questions, problems or operational technical matters of this subcontract with the Project Manager or higher line management, or Subcontract Administrator.

2. Interpret contract documents.

3. Assist in obtaining permits and approvals.

4. Control use of site.

1.6 FIELD QUALITY CONTROL

A. Contractor shall inspect work to assure performance in compliance with requirements of Contract Documents.

B. Prior to scheduling for a substantial completion (punch list) walk-thru Contractor shall conduct an inspection to insure that work has been completed. Upon issuance of punch list corrections and omissions supervise all work to complete identified items.

C. At final completion inspect and determine that all work is complete. Verify that site has been cleaned and all temporary facilities have been removed.

1.7 DEMONSTRATION

A. Equipment Start-up

1. Provide a minimum of seven days notice to Owner prior to start-up of each item.
2. Ensure that each piece of equipment or system is ready for operation.
3. Execute start-up under supervision of responsible persons in accordance with manufacturer's and Owner's instructions.
4. Perform required testing and balancing.
5. Provide written documentation of all tests, date of tests and results. Any test deemed unacceptable will be corrected and retested at the Contractor's expense.

B. Training

1. Demonstrate operation and maintenance of products to Owner's personnel prior to Beneficial Occupancy.
2. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, seasonal operation, and shutdown of each piece of equipment.

1.8 SCHEDULES

A. The Contractor must provide a work schedule giving NREL two weeks (10 working days) notice prior to work on the job site.

B. Contractor shall:

1. Coordinate schedules with all subcontractors.
2. Monitor schedules as work progresses.
3. Identify potential variances between schedules and probable completion dates for each phase.
4. Recommend adjustments in schedule to meet required completion dates.
5. Adjust schedules of subcontractors as required.
6. Document changes in the schedule.
7. Observe work of each subcontractor to monitor compliance with schedule.
8. Verify labor and equipment are adequate for the work and the schedule.
9. Verify product procurement schedules are adequate.
10. Verify product deliveries are adequate to maintain schedule.

END OF SECTION

SECTION 013200
CONSTRUCTION PROGRESS DOCUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. The Contractor shall prepare and submit to the Owner estimated construction progress schedules for the work with sub-schedules of related activities that are essential to its progress.
2. The construction schedule shall respond to phasing discussed in Section 010000 of these Specifications, and shall be reviewed and approved by NREL. The schedules shall be revised and resubmitted periodically to show construction progress and effect on milestone dates.

B. Related Sections

1. Section 011100 - Summary of Work
2. Section 013300 - Submittals, Shop Drawings, Product Data and Samples

1.2 SYSTEM DESCRIPTION

A. Schedule Form

1. Prepare in the form of horizontal bar chart with separate bars for each trade or operation. Time scale to show on a weekly basis.
2. Listings shall be by chronological order of start for each item and identified by major specification section numbers.

B. Content of Schedules

1. Show the complete sequence of construction by activity with beginning and completion dates for each item. Specifically include:

~~a. Site clearing~~

~~b. Foundation work~~

~~c. Structural frame~~

~~d. Roofing~~

~~e.~~a. Subcontractor work

~~f.~~b. Equipment installations

~~g.~~c. Testing of Equipment

~~h.~~d. Operational check out

~~i.~~e. Finishing

~~j. Paving~~

2. Schedule submittals for shop drawings, product data and samples showing the dates for Contractor submittal, dates required for owner furnished products to coordinate with construction activity, dates required for approved submittals from the Owner, and delivery dates for all major product items.

C. Progress Revisions

1. Indicate progress of each activity to date of submission showing changes occurring since previous schedule and revised projections of progress and completion.

2. Provide a narrative report defining problem areas, anticipated delays, recommended corrective action and effect of changes on subcontractors.

1.3 SUBMITTALS

A. Comply with Section 013300.

B. Submit revised progress schedules with each application for payment and as necessary to promptly reveal major delays that affect project completion.

C. Distribute copies to subcontractors and other concerned parties.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 013250
PROJECT MEETINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Pre-Construction Conferences
    a. Prior to the commencement of construction, the Contractor and major Sub-Contractors shall attend a pre-construction conference at the site of the construction where administrative construction procedures and instruction shall be discussed. These items include:
        1) Project representatives
        2) Construction superintendent
        3) Contract time
        4) Construction scheduling
        5) Progress payments
        6) Change orders
        7) Daily operations
        8) Safety programs
        9) Labor requirements
        10) Personnel
        11) Material and equipment access
        12) Construction methods and techniques
        13) Facilities
        14) Taxes
        15) Partial occupancy prior to completion
        16) Final construction inspections
        17) Other miscellaneous items
2. Progress Meetings
    a. Weekly progress meetings will be scheduled for the Owner, Architect, and Contractor. Suggested agenda items include:
        1) Review of work progress since previous meeting.
        2) Field observations, problems and conflicts.
        3) Problems which impede construction schedule.
        4) Review of off-site fabrication and delivery schedules.
        5) Corrective measures and procedures to regain project schedule.
        6) Revisions to construction schedule.
        7) Coordination of schedules.
        8) Progress and schedule during succeeding work period.

9) Review submittal schedules and expedite as required.

10) Maintenance of quality standards.

11) Pending changes and substitutions.

b. Personnel whose presence is requested are required to attend.

c. Discussions agreed upon during those meetings are binding on all parties, if all parties agree. If consensus is not reached, disputes shall be settled as provided for in the General Conditions. Owner, Project Manager and Contractor's Superintendent will document such meetings.

PART 2 - PRODUCTS (NOT USED)

PART 3 - PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 013300
SUBMITTALS, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Administrative and procedural requirements for submittal and review of product data, shop drawings, samples and similar items required by the Specifications.

B. Related Sections

1. Refer to sections of Divisions 2 through 33 for additional submittal requirements.
2. General and Supplementary Conditions of the Contract, drawings, and other Division 1 Specification sections apply to work of this Section.

1.2 SUBMITTALS

A. Submittal Types

1. Submittals prior to award of contract
   a. Refer to Bid Preparation Instructions and other Contract Documents for general submittal data, including but not limited to:
      1) Performance and payment bonds (prior to Notice to Proceed)
      2) Insurance certificates
      3) List of subcontractors
      4) Safety plan
      5) Schedules (prior to Notice to Proceed)
      6) Schedule of Values
   b. To be submitted two days prior to award of contract
   c. Rejection of any submittal may be cause for not awarding the Contract and rejection of the bid.
2. Administrative submittals
   a. Refer to other Division 1 sections and other Contract Documents for requirements for administrative submittals. Such submittals include but are not limited to:
      1) Schedules
      ~~2) Excavation permit~~
      ~~3)~~2) Applications for payment
      ~~4)~~3) Environmental control plans
      ~~5)~~4) Contractor qualifications
   b. To be submitted five days after award of contract
   c. Such submittals are for information and record and do not require action on the part of the Owner except where not in conformity with the Contract Documents. If such non-conformity is observed, the Owner will notify the Contractor within one week of receipt of documents. Failure to observe or notify by the Owner does not relieve the Contractor of compliance with Contract Documents.

3. Product Data
   a. Submit within 20 working days after Award of Contract
   b. Collect Product Data into a single submittal for each element of construction or system. Product Data includes printed information, such as manufacturer's installation instructions, catalog cuts, standard color charts, roughing-in diagrams and templates, standard wiring diagrams, and performance curves.
      1) Mark each copy to show applicable choices and options. Where printed Product Data includes information on several products that are not required, mark copies to indicate the applicable information. Include the following information:
         a) Manufacturer's printed recommendations.
         b) Compliance with trade association standards.
         c) Compliance with recognized testing agency standards.
         d) Application of testing agency labels and seals.
         e) Notation of dimensions verified by field measurement.
         f) Notation of coordination requirements.
      2) Do not submit Product Data until compliance with requirements of the Contract Documents has been confirmed.
   c. Submittal is for information and record, unless otherwise indicated; therefore, initial submittal is final submittal unless returned promptly by the Owner marked with an "action" which indicates an observed non-compliance.
   d. Submit 6 paper copies and 1 electronic copy as specified above. Where applicable, include additional copies for maintenance manuals. Submit a cover letter to show Contractor's review and action. Each set shall be identical and be in a hard back binder with the project title and contract number and shall include:
      1) Title page with project name, contract number, Owner's name, General Contractor's name, major Subcontractor's names, and date of submittal.
      2) Index page indicating section number in the submittal, related section, and paragraph numbers in the specification, and item title.
      3) Tab indexed section divides.
      4) A section title page indicating item name, manufacturer, model numbers, include as applicable, sizes, capacities, performance data, printed, descriptive literature, drawings, illustrations, diagrams, catalog cut sheets, etc. Any proposed deviations or substitutions to specified requirements shall be clearly indicated.
      5) Submittals of samples of material, i.e. color boards, glazing, roofing, etc, may be delivered separately and may also be limited to one sample. However, there must be a corresponding section in the submittal binder identifying all the applicable data in the item above.
   e. The Owner will review and return two sets to the Contractor.
   f. The submittal set is reviewed by the Owner and returned with notations of acceptance, rejection, or changes required for each submittal. This review should not take longer than 15 working days.
4. Shop Drawings

a. Submit shop drawings within 20 working days after return of approved Product Data submittal for work required to maintain construction schedule. Submit remaining shop drawings in accordance with the submittal schedule to allow for review and implementation and maintain the Construction Schedule.

b. Submit newly prepared information drawn accurately to scale. Highlight, encircle, or otherwise indicate deviations from the Contract Documents. Do not reproduce Contract Documents or copy standard information as the basis of Shop Drawings. Standard information prepared without specific reference to the Project is not a Shop Drawing.

c. Shop Drawings include fabrication and installation drawings, setting diagrams, schedules, patterns, templates and similar drawings. Include the following information:

   1) Dimensions.

   2) Identification of products and materials included by sheet and detail number.

   3) Compliance with specified standards.

   4) Notation of coordination requirements.

   5) Notation of dimensions established by field measurement.

d. Submit initially, one correctable, translucent, reproducible print and four blue- or black-line prints.

e. Contractor will provide prints of marked up sepia as may be required for his use and that of his Subcontractors and suppliers.

f. Final submittal shall be delivered to the Owner with sufficient copies so that desired distribution can be made by Contractor, three copies to the Owner, and one each to the Contractor's field office, his home office, the Record Documents, the fabricator, and any others involved in the submittal. Provide 1 electronic copy. See NREL CAD Manual for required format.

g. If initial submittal becomes final submittal, provide sufficient additional copies that may be needed to meet these requirements.

h. Where shop drawings are indicated to be submitted for "information only", submit three sets of prints to Owner and retain one set for Project Record Documents.

5. Samples

a. Submit full-size, fully fabricated Samples cured and finished as specified and physically identical with the material or product proposed. Samples include partial sections of manufactured or fabricated components, cuts or containers of materials, color range sets, and swatches showing color, texture, and pattern.

b. Mount, display or package Samples in the manner to facilitate review of qualities indicated. Include the following:

   1) Generic description of the Sample.

   2) Sample source.

   3) Product name or name of the manufacturer.

   4) Compliance with recognized standards.

   5) Availability and delivery time.

c. Submit Samples to Owner who will review solely for kind, color, pattern, and texture, for a final check of these characteristics with other elements, and for a comparison of these

characteristics between the final submittal and the actual component as delivered and installed.

1) Where variation in color, pattern, texture, or other characteristic is inherent in the material or product represented, submit at least 3 multiple units that show approximate limits of the variations.

2) Refer to other Sections for Samples to be returned to the Contractor for incorporation in the Work. Such Samples must be undamaged at time of use. On the transmittal, indicate special requests regarding disposition of Sample submittals.

d. Preliminary Submittals:

1) Where Samples are submitted for selection of color, pattern, texture, or similar characteristics from a range of standard choices, submit a full set of choices for the material or product.

2) Preliminary submittals will be reviewed and returned with the Architect's mark indicating selection and other

e. Final Submittals:

1) Except for Samples illustrating assembly details, workmanship, fabrication techniques, connections, operation, and similar characteristics, submit 3 sets.

2) One set will be returned marked with the action taken.

f. Maintain sets of Samples, as returned, at the Project Site, for quality comparisons throughout the course of construction.

1) Unless noncompliance with Contract Document provisions is observed, the submittal may serve as the final submittal.

2) Sample sets may be used to obtain final acceptance of the construction associated with each set.

g. Distribution of Samples:

1) Prepare and distribute additional sets to subcontractors, manufacturers, fabricators, suppliers, installers, and others as required for performance of the Work. Show distribution on transmittal forms.

~~h. Field Samples and Mock-Ups:~~

~~1) Field samples and mock-ups specified in individual sections are full-size examples erected on-site to illustrate finishes, coatings, or finish materials and to establish the Project standard.~~

~~2) Comply with submittal requirements to the fullest extent possible. Process transmittal forms to provide a record of activity.~~

6. Selections Submittal

a. Where selections of colors, patterns, textures are specified to be made by the Owner, assemble complete samples of all specified or approved products for all specification sections and submit to Owner. Review specifications and assemble all such samples for a combined single submittal. Indicate on the transmittal the latest date for selections to be made for each item to permit delivery of material in accordance with Progress Schedule.

b. Owner's action is limited solely to the specified selections or rejection of submittal items not in accordance with specifications.

7. Test Report Submittal
    a. Inspection and Test Reports:
        1) Where standard tests are specified for products, including equipment which tests are not performed at the job site, follow procedures for Product Data. For field inspection and tests, specified to be performed by independent agencies, such agencies shall transmit directly to receiving entity.
        2) Distribute 5 hard copies and 1 electronic copy of test reports by the testing agency as follows:
            a) General Contractor's Project Manager (1)
            b) General Contractor's Field Superintendent (1)
            c) Owner (2)
            d) Record Documents (1) and electronic copy
            e) Other copies as directed
8. Contract Close-out Submittal
    a. Refer to Section 017700, Contract Closeout Procedures, for additional requirements.
    b. Near the completion of the construction submit the following documents, but not limited to:
        1) Final payment request
        2) Final statement of Contract sum
        3) Final punch list
        4) Consent of Surety
        5) Liquidated damages settlement statement
        6) Evidence of continuing insurance coverage
        7) Project record documents
        8) Operating and Maintenance Manuals
        9) Test and Balance Reports for mechanical systems
        10) Printed Warranties
        11) Parts and maintenance materials
    c. With the exception of the Operating and Maintenance Manuals, the review of the documents will take 1 or 2 days. The Operating and Maintenance Manuals should be reviewed in 10 working days or less. Under no circumstances will the construction contract be closed out or 100% of the funds turned over to the Contractor without these final submittals being received and approved.

B. Submittal Procedures
1. General
    a. Make submittals from Contractor to the Owner after Contractor has reviewed each submittal and indicated his action thereon, except for samples and selection submittals.
    b. For Type 3 submittals not provided within 20 working days after return of approved Product Data submittals and Type 4 submittals, deliver submittals to Technical Representative at each weekly construction meeting in accordance with the submittal schedule noted below.

2. Scheduling
    a. Prepare a separate listing and schedule, organized by related specification section number sequence, showing the principal work-related submittals and their initial submittal dates as required for coordination of the work. For Type 3 and Type 4 submittals, submit listing and schedule within five days after notice to proceed with construction or commencement of work.
    b. Submit with Contractor's construction schedule, a complete schedule of submittals.
        1) Coordinate submittal schedule with the list of subcontracts, schedule of values and the list of products as well as the Contractor's construction schedule.
        2) Prepare the schedule in chronological order. Provide the following information:
            a) Scheduled date for the first submittal
            b) Related section number
            c) Name of subcontractor
            d) Description of the part of the work covered
            e) Scheduled date for resubmittal
            f) Scheduled date for Owner's final release or approval
3. Schedule Updating
    a. Revise the schedule after each meeting or activity, where revisions have been recognized or made.
    b. Issue the updated schedule concurrently with report of each meeting.
4. Coordination
    a. Coordinate the preparation and processing of submittals with the performance of construction activities. Transmit each submittal sufficiently in advance of performance of related construction activities to avoid delay.
    b. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals and related activities that require sequential activity.
    c. Coordinate transmittal of different types of submittals for related elements of the Work so processing will not be delayed by the need to review submittals concurrently for coordination.
        1) The Owner reserves the right to withhold action on a submittal requiring coordination with other submittals until all related submittals are received.
5. Processing:
    a. To avoid the need to delay installation as a result of the time required to process submittals, allow sufficient time for submittal review, including time for resubmittals.
    b. Partial submission or return of submittals are not acceptable.
    c. Allow 10 working days for initial review. Allow additional time if processing must be delayed to permit coordination with subsequent submittals.
    d. Normally one resubmission is allowed and should take place within 10 working days of the returned documents and the follow on review should take less than five working days. With the exception of the single copy held by the Owner, all five copies are returned to the

Contractor or vendor for correction. They are only distributed when all submittal items have been approved. Multiple submissions are not acceptable.

e. If an intermediate submittal is necessary, process the same as the initial submittal.

f. No extension of Contract Time will be authorized because of failure to transmit submittals to the Owner sufficiently in advance of the Work to permit processing.

6. Submittal Preparation:

a. Place a permanent label or title block on each submittal for identification. Indicate the name of the entity that prepared each submittal on the label or title block.

1) Provide a space approximately 4 by 5 inches (100 by 125 mm) on the label or beside the title block on Shop Drawings to record the Contractor's review and approval markings and the action taken.

2) Include the following information on the label for processing and recording action taken.

a) ~~Project name.~~NWTC Bldg 251 HVAC, Lighting and Ceiling Upgrades

b) Date.

c) Name and address of the Owner.

d) Name and address of the Contractor.

e) Name and address of the subcontractor.

f) Name and address of the supplier.

g) Name of the manufacturer.

h) Number and title of appropriate Specification Section.

i) Drawing number and detail references, as appropriate.

7. Submittal Transmittal:

a. Package each submittal appropriately for transmittal and handling. Transmit each submittal from the Contractor to the Owner using a transmittal form. Submittals received from sources other than the Contractor will be returned without action.

1) On the transmittal, record relevant information and requests for data. On the form, or separate sheet, record deviations from Contract Document requirements, including variations and limitations. Include Contractor's certification that information complies with Contract Document requirements.

C. Submittal Matrix

1. The following Submittal Matrix is provided as a guide for preparing the submittal schedule, and as the submittal log basis.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

SECTION 013300
SUBMITTALS, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

NWTC Bldg 251 HVAC, Lighting and Ceiling Upgrades

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Submittal Matrix

The following matrix identified by specification sections the submittals, mock-ups, special warranties, and operating and maintenance data required. It is provided as a convenience and checklist. Specific requirements for submittals and procedures will be found in other sections of Division 1 and in the individual sections of Divisions 2 through 16. The matrix may not be entirely complete and correct in which case the requirements of individual sections will govern.

Spec. Sect.	Admn./ Sched.	Prod. Data	Shop Dwgs.	Sample	Mockup	Test/ Report	Spec. Warr.	Cert.	O&M Manual	Coord. Dwgs.	Equip. Sched.	Design Calcs.	Record Docs.
024119	X												X
072100		X											
078413		X									X		
095113		X		X									
210500		X	X			X		X	X				X
210548		X							X				
211300		X											
226113		X											
230500		X							X				
230519		X							X				
230523		X											
230529		X							X				
230548		X							X				

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Spec. Sect. ~~23 0553~~	Admn./ Sched.	Prod. Data	Shop Dwgs.	Sample ~~X~~	Mockup	Test/ Report	Spec. Warr.	Cert.	O&M Manual	Coord. Dwgs.	Equip. Sched. ~~X~~	Design Calcs.	Record Docs.
230593						X	X	X					
230594						X							
230700		X									X		
230900		X	X						X				
232113		X											
232123		X	X						X				
233113		X							X	X			X
233300		X	X										
233600		X	X						X				
233713		X		X		X				X			
260500		X	X	X		X			X				X
260519		X											
260526		X				X							
260529		X	X										
260533		X	X										
260553		X											

Spec. Sect.	Admn./ Sched.	Prod. Data	Shop Dwgs.	Sample	Mockup	Test/ Report	Spec. Warr.	Cert.	O&M Manual	Coord. Dwgs.	Equip. Sched.	Design Calcs.	Record Docs.
260800						X			X				X
260923		X		X		X			X				
262416		X				X							
262726		X				X			X				
265100		X	X	X	X	X	X		X				

END OF SECTION

SECTION 014100
REGULATORY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

1.2 REFERENCES

A. All references to Codes, Specifications and Standards referred to in the Technical Specifications and on the Drawings shall mean the Latest Edition, Amendment and/or Revision of such Referenced Standard in effect as of the date of these Contract Documents unless otherwise specifically indicated. The work of this Contract shall be completed under the applicable provisions of:

B.

	ABBREVIATION	TITLE
1.	AASHTO	American Association of State Highway and Transportation Officials
2.	ABMA	American Boiler Manufacturers Association
3.	ADA	Americans With Disabilities Act
4.	ACI	American Concrete Institute
5.	AFI	Air Filter Institute
6.	AGA	American Gas Association
7.	AIA	American Institute of Architects
8.	AISC	American Institute of Steel Construction
9.	AISI	American Iron and Steel Institute
10.	AMA	Acoustical Materials Association
11.	AMCA	Air Moving and Conditioning Association
12.	ANSI	American National Standards Institute
13.	AREA	American Railway Engineering Association
14.	ARI	Air Conditioning Refrigeration Institute
15.	ASA	Aluminum Siding Association
16.	ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
17.	ASME	American Society of Mechanical Engineers
18.	ASSE	American Society of Sanitary Engineering
19.	ASTM	American Society of Testing Materials
20.	AWI	American Woodwork Institute
21.	AWS	American Welding Society
22.	AWWA	American Water Works Association, Inc.
23.	BIA	Brick Institute of America
24.	BOCA	Building Officials Code Administration
25.	CBM	Certified Ballasts Manufacturing

26. CISPI Cast Iron Soil Pipe Institute
27. SC Commercial Standards
28. CSI Construction Specifications Institute
29. EIA Electronic Industries Association
30. ETL Electrical Testing Lab
31. FM Factory Mutual Corporation
32. FS Federal Specification
33. IBC International Building Code
34. IBR Institute of Boiler & Radiator Manufacturers
35. ICC International Code Council
36. ICC Interstate Commerce Commission
37. IES Illuminating Engineering Society
38. IRI Industrial Risk Insurers
39. JIC Joint Industrial Council
40. MLMA Metal Lath Manufacturer's Association
41. MSS SP Manufacturer's Standardization Society of the Valve & Fitting Industry (Standard Practice)
42. NCMA National Concrete Masonry Association
43. NEC National Electric Code
44. NEMA National Electrical Manufacturers Association
45. NFC National Fire Code
46. NFPA National Fire Protection Association
47. OSHA Occupational Safety and Health Act
48. PDI Plumbing and Drainage Institute
49. SMACNA Sheet Metal and Air Conditioning Contractors National Association
50. SSPC Steel Structures Painting Council
51. UL Underwriter's Laboratories
52. USDTS U.S. Dept. of Transportation Specifications
53. USS United States Standard
54. And other codes as listed in Specific Divisions and Sections of the Specifications as they apply to the Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 014200
REFERENCES

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

A. General

1. Reference standards are incorporated into the Specifications by referring to a number, title, or other designation of the standard referenced. The provisions of a standard so referenced are a part of the Section of the Specifications in which the reference is made, and thus part of the Contract Documents, just as though the standard were duplicated in the Section in its entirety.
2. All references to codes, Specifications and Standards referred to in the Technical Specifications and on the Drawings shall mean the Latest Edition, Amendment and/or Revision of such Referenced standard in effect as of the date of these Contract Documents unless otherwise specifically indicated.

B. The work of this Contract shall be completed under the applicable provisions of the following references including but not limited to:

1. ABBREVIATION TITLE

a.	AASHTO	American Association of State Highway and Transportation Officials
b.	ABMA	American Boiler Manufacturers Association
c.	ADA	Americans With Disabilities Act
d.	ACI	American Concrete Institute
e.	AFI	Air Filter Institute
f.	AGA	American Gas Association
g.	AIA	American Institute of Architects
h.	AISC	American Institute of Steel Construction
i.	AISI	American Iron and Steel Institute
j.	AMA	Acoustical Materials Association
k.	AMCA	Air Moving and Conditioning Association
l.	ANSI	American National Standards Institute
m.	AREA	American Railway Engineering Association
n.	ARI	Air Conditioning Refrigeration Institute
o.	ASA	Aluminum Siding Association
p.	ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
q.	ASME	American Society of Mechanical Engineers
r.	ASSE	American Society of Sanitary Engineering
s.	ASTM	American Society of Testing Materials
t.	AWI	American Woodwork Institute
u.	AWS	American Welding Societyp

v.	AWWA	American Water Works Association, Inc.
w.	BIA	Brick Institute of America
x.	BOCA	Building Officials Code Administration
y.	CBM	Certified Ballasts Manufacturing
z.	CISPI	Cast Iron Soil Pipe Institute
aa.	SC	Commercial Standards
bb.	CSI	Construction Specifications Institute
cc.	EIA	Electronic Industries Association
dd.	ETL	Electrical Testing Lab
ee.	FM	Factory Mutual Corporation
ff.	FS	Federal Specification
gg.	IBR	Institute of Boiler & Radiator Manufacturers
hh.	ICC	International Code Council
ii.	ICC	Interstate Commerce Commission
jj.	IES	Illuminating Engineering Society
kk.	IRI	Industrial Risk Insurers
ll.	JIC	Joint Industrial Council
mm.	MLMA	Metal Lath Manufacturer's Association
nn.	MSS SP	Manufacturer's Standardization Society of the Valve & Fitting Industry (Standard Practice)
oo.	NCMA	National Concrete Masonry Association
pp.	NEC	National Electric Code
qq.	NEMA	National Electrical Manufacturers Association
rr.	NFC	National Fire Code
ss.	NFPA	National Fire Protection Association
tt.	OSHA	Occupational Safety and Health Act
uu.	PDI	Plumbing and Drainage Institute
vv.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
ww.	SSPC	Steel Structures Painting Council
xx.	UL	Underwriter's Laboratories
yy.	IBC	International Building Code
zz.	USDTS	U.S. Dept. of Transportation Specifications
aaa.	USS	United States Standard

bbb. And other codes as listed in Specific Divisions and Sections of the Specifications as they apply to the Work.

C. Incorporation of Standards into the Specifications

1. Part 1 - General, of a Section of the Specifications contains a list of the standards that are referenced in Part 2 - Products, and Part 3 - Execution, of the Section. The list is usually under a heading titled "References," and contains the following information:

   a. The full names of the standards organizations that have authored the specified standards;

   b. The initials or acronyms by which the respective organizations are referred in Parts 2 and 3 of the Section; and

   c. The number/letter designations and full titles of the referenced standards.

2. The list in Part 1 is only a form of index; it is not the place where the standards are incorporated into the Section, unless there are words in that location, which specifically say so.

3. The reference standards listed in Part 1 are incorporated into the Section in Parts 2 and 3 (unless the specific wording to do so is included in Part 1, as mentioned in the preceding paragraph).

4. In Parts 2 and 3, the standard is generally referred to simply by the acronym of the authoring standards organization and the number/letter designation of the standard proper (e.g., ASTM A36). The wording of the reference provision may be as explicit as, "Provide structural steel that complies with the provisions of ASTM A36", or it may only say, "Structural steel: ASTM A36". Both approaches are of equal validity in making the standard a part of the Section.

5. Some Sections may not contain the Part I article "References." Lack of the article "References," or text of a similar intent, in a Section does not invalidate the incorporation into the Section of the standards, which may be referenced in Parts 2 or 3 of the Section.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 015000
TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide temporary facilities and controls needed for the Work including, but not necessarily limited to:

   a. Temporary utilities such as water, electricity, and telephone.

   b. Field office for the Contractor's personnel. Offices for one NREL person and conference space for Project use, including reasonable periodic cleaning of space.

   c. Sanitary facilities and bottled drinking water for use by NREL personnel and as needed for Contractor's personnel.

   d. Enclosures such as tarpaulins, barricades, and canopies.

   e. Project signage to insure safety.

   ~~f. Project construction sign~~

      ~~1) Include the names of Owner, Project, Architect and Contractor.~~

      ~~2) Sign to be 4' 0" x 8' 0", painted.~~

      ~~3) Layout and colors to be approved by Owner.~~

B. Related Sections

1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.

~~2. Permanent installation and hookup of the various utility lines are described in other Sections.~~

~~3.~~2. Coordinate points of access and distribution of temporary facilities with NREL project manager.

1.2 QUALITY ASSURANCE

A. Comply with governing regulations and utility company regulations and recommendations for the construction of temporary facilities, including but not necessarily limited to, code compliances, permits, inspections, testing, and health and safety compliances.

1.3 DELIVERY, STORAGE, AND PROTECTION

A. Maintain temporary facilities and controls in proper and safe condition throughout progress of the Work.

1.4 PROJECT/SITE CONDITIONS

A. Provide temporary facilities and services at the time first needed at the site and maintain, expand, and modify facilities as needed throughout the construction period and do not remove until no longer needed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Utilities

1. Water

a. Provide, if necessary, temporary piping and water supply and, upon completion of the Work, remove such temporary facilities.

2. Electricity

a. Provide necessary temporary wiring and, upon completion of the Work, remove such temporary facility.

b. Provide area distribution boxes located so that the individual trades may furnish and use 100 ft maximum length extension cords to obtain power and lighting at points where needed for work, inspection, and safety.

c. Owner will pay cost of electric power.

3. Telephone

a. Make necessary arrangements and pay costs for installation and operation of telephone service to the Contractor's office and provide a minimum of one line for exclusive NREL use. NREL will pay its long distance costs.

4. Fire Protection

a. Comply with OSHA requirements.

b. Comply with Fire Department Regulations.

c. Maintain an effective housekeeping program.

2.2 MANUFACTURED UNITS

A. Field Offices and Sheds

1. Contractor's facilities

a. Provide a heated and insulated field office building and sheds, adequate in size and accommodation for Contractor's offices, supply, and storage, and for NREL personnel as described above.

~~b. Within the Contractor's facilities, provide enclosed space adequate for holding project meetings. Furnish with table, chairs, and utilities.~~

2. Sanitary facilities

a. Provide temporary sanitary facilities in the quantity required for use by all personnel.

b. Maintain in a sanitary condition at all times.

3. All trailers will be securely tied down and skirted as per details shown in the City of Golden and/or Jefferson County requirements for high wind exposure.

B. Enclosures

1. Provide and maintain for the duration of construction all scaffolds, tarpaulins, canopies, warning signs, steps, platforms, bridges, and other temporary construction necessary for proper completion of the Work in compliance with pertinent safety and other regulations.

PART 3 - EXECUTION

3.1 PREPARATION

A. Disruption of Facilities

1. Contractor is required to minimize disruptions of Owner's normal or general public activities by his performance of the work. Comply with governmental authorities, if disruption of public facilities is inevitable.

B. Access and Parking

1. Access to the site for delivery of construction material or equipment or for construction operations shall be made only from locations designated by the Owner.

2. All parking on the site is under control and authority of Owner. All on site parking is by Owner approval only. Parking for individual cars within project property lines is limited and spaces will be available only for General Contractor's Job Superintendents and "visitors". All other cars shall secure parking to park on site where directed, if available, or shall park off site.

3.2 FIELD QUALITY CONTROL

A. Rodent and Vermin Control

1. Institute an effective program of rodent and vermin control for the entire site within the construction limits approved by NREL. Cooperate with local authorities.

2. Provide marked metal containers for all edible rubbish and enforce their use by all employees. Containers shall be emptied and the contents removed from the site as often as required to maintain an adequate rodent and vermin control program.

3. If the program utilized is not effective, take whatever steps are necessary to rid the project of rodents and vermin, and such action shall not be the basis of claim for additional compensation of damages.

B. Water and Snow Control

1. From the commencement to the completion of the work, keep all parts of the site and the Project free from accumulation of water.

2. Supply, maintain and operate all necessary pumping and bailing equipment.

3. Remove snow and ice as necessary for the protection and execution of the work, and protect the work against weather damage.

3.3 PROTECTION

A. Maintain temporary facilities and controls as long as needed for safe and proper completion of the Work.

B. Remove such temporary facilities and controls as rapidly as progress of the Work will permit, or as directed by the Owner.

C. Security

1. Temporary Security

a. Watchman is not required, but contractor is responsible for all loss and damage in area under contractor's control.

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SECTION 015050
CONSTRUCTION WASTE MANAGEMENT

PART 1 - GENERAL

1.1 WASTE MANAGEMENT GOALS

A. GENERAL WASTE MANAGEMENT GOALS:

1. The Owner has established that this Project shall generate the least amount of waste possible.
2. The Contractor shall employ processes which ensure the generation of as little waste as possible and shall avoid the generation of waste due to the following:
   a. Over-packaging
   b. Error
   c. Poor planning, layout
   d. Over ordering
   e. Breakage
   f. Mishandling
   g. Contamination
   h. Damage from weather
3. Of the inevitable waste that is generated, as many of the waste materials as economically feasible shall be reused, salvaged, or recycled.
4. Waste disposal in landfills shall be minimized to the greatest extent possible.

B. WASTE DIVERSION GOALS:

1. Diversion Goals: A minimum 50% of total Project waste shall be diverted from landfill. The following waste categories, at a minimum, shall be diverted from landfill:

~~a. Land clearing debris~~

~~b.~~a. Clean dimensional wood, pallet wood

~~c.~~b. Plywood, OSB, and particleboard

~~d.~~c. Concrete

~~e.~~d. Bricks

~~f.~~e. Concrete Masonry Units (CMUs)

~~g. Asphalt roofing shingles~~

~~h.~~f. Cardboard, paper, packaging

~~i. Asphalt roofing shingles~~

~~j.~~g. Metals

~~k.~~h. Gypsum drywall (unpainted)

~~l.~~i. Paint

~~m.~~j. Glass

~~n.~~k. Plastics

~~o.~~l. Carpet and pad

~~p.~~m. Beverage containers

1.2 DESCRIPTION

A. WORK INCLUDED:

1. Waste Management Plan development and implementation.
2. Meetings: goals, issues and training for the Waste Management Plan.
3. Techniques to minimize waste generation.
4. Sorting and separation of waste materials.
5. Recycling: recycling of materials which cannot be reused or sold.
6. Records keeping: keeping of receipts and records of salvaged, recycled or landfilled materials.

B. RELATED SECTIONS:

1. Division 2 Section – Selective Structure Demolition.

1.3 REFERENCES, RESOURCES

A. GUIDES: The following publications list agencies and businesses in the reuse, recycling and salvage business community.

1. Business Reuse and Recycling Catalog: Available from Calmax: California Materials Exchange of the California Integrated Waste Management Board (916-255-2369).
2. Waste Spec: Model Specifications for Construction Waste Reduction, Reuse, and Recycling. Available from the Triangle J Council of Governments (919-549-0551).

1.4 SUBMITTALS

A. WASTE MANAGEMENT PLAN: Prior to any waste removal, the Contractor shall submit to the Owner a Waste Management Plan. The Plan shall contain the following:

1. Analysis of the estimated job site waste to be generated, including types and quantities. Use estimate sheets provided.
2. Proposed Alternatives to Landfilling: Contractor shall prepare a list of each material planned to be salvaged, re-used, or recycles during the course of the Project.
3. Meetings: Contractor shall conduct Construction Waste Management meetings. Meeting shall include subcontractors affected by the Waste Management Plan. At a minimum, waste management goals and issues shall be discussed at the following meetings:
   a. Pre-bid meeting.
   b. Pre-construction meeting.
   c. Regular job-site meetings.
4. Waste Management Plan Implementation
   a. Manager: The Contractor shall designate an on-site party (parties) responsible for instructing workers and subcontractors, and overseeing and documenting results of the Waste Management Plan for the project.
   b. Distribution: The Contractor shall distribute copies of the Waste Management Plan to the Job Site Foreman, each Subcontractor, and the Owner.

c. Instruction: The Contractor shall provide on-site instruction of appropriate separation, handling, and recycling, salvage, reuse and return methods to be used by all parties at the appropriate stages of the Project.

d. Separation facilities: The Contractor shall lay out and label a specific area to facilitate separation of material for reuse, salvage, recycling, and return. Recycling and waste bin areas are to be kept near and clean and clearly marked in order to avoid contamination or mixing materials.

e. Hazardous wastes: Hazardous wastes shall be separated, stored, and disposed of according to local, state and federal regulations.

B. PROGRESS REPORTS

1. The Contractor shall submit (monthly, quarterly, at end of job), a ~~Waste Management Progress Report~~Construction Waste Tracking Log. (see form provided by NREL) The report shall contain the following information:

a. The amount (in tons or cubic yards) of material landfilled from the Project, and the identity of the landfill. Include legible copies of manifests, weight tickets, and receipts. Manifests shall be from recycles and/or disposal site operators that can legally accept the materials for the purpose of reuse, recycling or disposal.

b. For each material recycled, reused, or salvaged from the Project, provide the following:

1) Amount (in tons or cubic yards)

2) Date removed from the job site

3) Receiving party

4) Indicate the project information, including project title, name of company completing form, beginning and ending dates of period covered by summary form.

PART 2 - PRODUCTS: (NOT USED)

PART 3 - EXECUTION:

3.1 WASTE MANAGEMENT PLAN IMPLEMENTATION

A. Coordinate waste materials handling and separation for all trades and document results of the Waste Management Plan.

B. Provide separation, handling, transportation, recycling, salvage, and landfilling for all service or landfill, and facility fee. Use ~~Appendix A – Materials Disbursal Worksheet and Appendix B – Waste Management Progress Report Worksheet~~Construction Waste Tracking Log provided by NREL.

C. Do not handle, separate, store, salvage, or recycle hazardous materials. Contact Project Manager if hazardous materials are encountered.

END OF SECTION

APPENDIX A

MATERIALS DISBURSAL WORKSHEET

Instructions:

1) List materials which are disposed of together in left hand column.

2) Fill in columns with relevant recycling/disposal data.

Date: _____

Project: _____

Report Period: _____

Materials	Total Amount Generated	Date Removed & Destination	Amount Reused on site	Amount Sold for Reuse	Amount Recycled	Amount Sent to Landfill
Wood						
Palettes						
Plywd, OSB, Part. Bd.						
Cardboard, Packaging						
Paper						
Metals						
Carpet, Pad						
Paint						
Gypsum Board						
Insulation						
Plastics						
Beverage Containers						
Concrete						
Masonry						
Asphalt						
Roofing						
Windows, Doors						
Plumbing Fixtures						
Cabinetry						

Describe any unusual circumstances encountered in the distribution of the materials listed above:

Describe any pre-construction information which would have helped in the process:

APPENDIX B

WASTE MANAGEMENT PROGRESS REPORT WORKSHEET

Instructions:

1) Complete one form for each material or material group leaving the job site, i.e., one each for wood, metals, mixed debris, etc.
2) Fill in all applicable columns using a consistent unit of measure for each material.

Date: _____

Project: _____

Material: _____

Job Site Waste	Tons / Cubic Yards	Cost/100% Landfill	Cost/Revenues	Cost of Handling	Cost of Transport	Total Cost/Revenues
Total Waste Generated						
% Reused on Site						
% Reused off Site						
% Recycled off Site						
% Alternate Landfill						
% Traditional Landfill						
Destination						

Describe any unusual circumstances encountered in the distribution of the materials listed above:

Describe any pre-construction information that would have helped in the process:

END OF SECTION

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SECTION 015610
PROJECT CONTROL FACILITIES

PART 1 - GENERAL

1.1 GENERAL

A. Nothing in this Section is intended to limit types and amounts of temporary work required, and no omission from this Section will be recognized as an indication by Architect that such temporary activity is not required for successful completion of the Work and compliance with requirements of Contract Documents.

B. Dispose of project control facilities at completion of the Project, unless otherwise requested in writing by the Owner or specified. Repair damage caused by the installations.

1.2 PROJECT SIGNAGE

A. General

1. Do not display signs or advertising on the premises without the approval of the Owner.

B. Directional Signs

1. Provide the following signs legibly printed and weatherproof:

a. Directional signs to emergency telephone.

b. Phone number listing of the following at each emergency telephone.

Local fire department
Local police department
Local hospital emergency
Owner's security and fire department
First aid stations
Ambulance service
Local doctor on call

c. Directional signs to first aid station.

d. Directional signs to nearest telephone.

e. Signs required for maintenance of traffic.

~~C. Project Identification Signs~~

~~1. General~~

~~a. Provide one Project identification sign. Locate sign where directed by the Owner.~~

~~b. Provide minimum sign dimensions of 4' x 8'.~~

~~c. Submit shop drawings for approval showing structure, exact dimensions, copy, confirmation of specified colors and typefaces, and location on site. Receive approval before erection.~~

~~d. Maintain sign until final acceptance of the Work, and repaint sign at least once in each 12-month period.~~

~~2. Sign construction~~

~~a. Fabricate sign of 3/4-inch minimum thickness, waterproof marine plywood, and 1/4-inch hardwood edge strips with mitered corners.~~

~~b. Include the rendering of project, project name, name of the Owner, the Architect and General Contractor on the sign.~~

~~c. Mount project sign on pressure preservative treated wood posts, 4 x 4 inch minimum, set in concrete, with 2 x 4 inch horizontal back bracing to 2 x 6 inch deadman anchors driven into soil.~~

~~d. Anchor field office sign to field office or mount on 2 x 2 inch pressure preservative treated wood post set in ground, or otherwise anchored as approved.~~

~~e. Paint fasteners through face of signs to match background.~~

~~f. Provide Sherwin-Williams Co. colors as follows:~~

~~1) Owner's panel: white, SW 2123 (Exterior).~~

~~2) Architect's panel: gray, SW 2115 (Exterior).~~

~~3) Contractor's panel: gray, SW 2115 (Exterior)~~

~~4) Field office signs: white, SW 2123 (Exterior)~~

~~5) Type: black, SW 2126 (Exterior).~~

1.3 WATER AND SNOW CONTROL

A. Water Control

1. From commencement to completion of the Work, keep all parts of the site and the Project free from accumulations of water.
2. Provide, maintain and operate necessary pumping, bailing and well pointing equipment that may be required for water control.

B. Snow Removal

1. Remove snow and ice, including plowing roads, as necessary for the protection and prosecution of the Work, and to protect the Work against weather damage.

1.4 SECURITY

A. Security Enclosures

1. Provide temporary enclosures and other construction required for protecting the Project from the exterior, for providing passageways, for the protection of openings, both exterior and interior, and at any other location where temporary enclosures and protection may be required.

B. Identification Badges

1. Badges will be required for Contractor and Subcontractor employees to limit the use of the Owner's premises. Cooperate with the Owner in establishing and working out the details of such identification system. Obtain badges in accordance with Owner's requirements.

C. Regulations and Use of Premises

1. Comply with Owner's plant, building, and grounds regulations in the use of the premises, including safety, fire and cleanliness.
2. Restrict construction activities and personnel to the designated area or areas established by the Owner. If the Contractor wishes to use an area other than that which is designated by the Owner, obtain written permission from the Owner prior to use of area requested.

~~**1.5 EXISTING UTILITIES**~~

~~A. Locations~~

1. The locations of utilities are shown using the best information available. No guarantee is given that the locations are absolutely accurate or that utilities other than those shown are not present.

2. Before starting construction, check with governing authorities and with public service organizations to ascertain the location of utilities that might interfere with the Work, and give due notice to organizations whose utilities will be affected by the operations.

3. Provide required temporary protection and indicators showing location of hidden or buried utilities and lines, and remove indicators when no longer required.

B. Maintenance and Moving

1. Maintain utilities not required to be moved or abandoned in accordance with the standard method employed by the utility involved and in such manner as to assure the safety of the public and of adjacent structures and utilities.

2. When it is deemed unsafe, impracticable, or impossible to construct the Work without moving a utility that is not required by the Contract Documents to be moved, notify the Owner. If the Owner so directs, notify the governing authority or public service organization concerned to have the utility moved. The work of moving the utility will be without expense to the Contractor.

3. When existing utilities and lines are disturbed unknowingly or accidentally and an emergency condition results, contact the governing authority or utility company immediately for instruction and emergency service. Pay for charges for emergency service and repairs.

1.61.5 TESTING AND INSPECTION

A. Refer to Section "Testing and Inspection Services".

1.71.6 ROOF AREAS

A. Roof Protection

1. Provide temporary roof protection needed for the Work, including temporary walkways and other temporary supporting structures, for moving and setting equipment. Construct such protection to bear on building structural members and at no point on roof deck alone, built and placed to properly distribute and support applied loads.

1.81.7 CONSTRUCTION FIRE PROTECTION

A. Fire Protective Measures

1. Take precautions to eliminate fire hazards.

2. Inspect the Project periodically with the Owner to detect possible fire hazards and advocate good housekeeping practices.

3. Enforce the following requirements:

a. Locate field offices and other temporary buildings at least 50 feet from new construction.

b. Do not park automobiles within the perimeter of buildings completed or under construction.

c.b. Do not store flammable liquids within perimeter of buildings completed or under construction.

d. Trucks and motor vehicles used in construction may be parked within buildings only when construction is in progress and vehicle operator is present.

e.c. Remove combustible debris from buildings every day. Remove other debris from buildings once each week.

~~f.~~d. Store materials and equipment that have been delivered in combustible containers in an orderly fashion. Locate portable approved fire fighting equipment in vicinity of such containers to be readily accessible until permanent building fire protection is available.

~~g.~~e. Stockpile no more than one day's supply of unpackaged combustible building materials in one location within a building. Store roofing materials, kettles, and bitumen-melting equipment outside of buildings at a minimum distance of 15 meters (50 feet) from any building including those under construction.

~~h. Temporary space heating equipment and systems: approved by Underwriters Laboratories Inc.~~

~~i. Install permanent fire protection water supply, fire extinguishing equipment, and fire protection systems at the earliest possible date. Make completed sections of fire protection water supply immediately serviceable for emergency use during building construction even though final testing or approvals have not been received. See Temporary Fire Standpipe System paragraph.~~

~~Provide and maintain a minimum of one fire extinguisher unit for each 232 square meters (2500 square feet) of floor area or fraction thereof at each floor level, including roof area, except provide no less than four extinguishers at any one level. An extinguisher unit shall consist of one, 6.8 kg (15 pound) ABC extinguisher. Owner may inspect this equipment; replace, immediately, equipment found to be faulty. Remove such equipment when construction is completed.~~

~~j. Provide and maintain a minimum of one fire extinguisher unit for each 232 square meters (2500 square feet) of floor area or fraction thereof at each floor level, including roof area, except provide no less than four extinguishers at any one level. An extinguisher unit shall consist of one, 9.5 liter (2 1/2 gallon) pressurized water extinguisher and one 6.8 kg (15 pound) dry chemical extinguisher. Protect extinguishers from freezing. Owner may inspect this equipment; replace, immediately, equipment found to be faulty. Remove such equipment when construction is completed.~~

~~k.~~f. Use only fire-resistant tarpaulins on the Project.

~~l.~~g. Perform cutting and welding operations in strict accordance with fire and safety regulations. Assume responsibility for damages resulting from negligence and from deviation from compliance with these regulations.

~~B. Temporary Fire Standpipe System~~

~~1. Provide a temporary fire standpipe system in all parts of building for use of fire department during construction.~~

~~2. Install permanent risers as floor slabs are cast, with capped, 64 mm (2 1/2 inch) hose valves on each floor and temporary cap or plug on top. Extend one riser at a time up so that remainder are available for use at all times.~~

~~a. Install permanent cross connections or provide temporary cross connections.~~

~~b. Provide temporary siamese connections to temporary or permanent cross connections.~~

~~3. Install one fire water service and one domestic water service at start of Project.~~

~~4. Maintain system dry during freezing conditions.~~

~~5. Provide temporary hose and nozzles as required by fire department.~~

~~1.9 TEMPERATURE AND WEATHER LOGS~~

~~A. Temperature Log~~

~~1. Provide and maintain approved maximum-minimum registering type thermometers throughout the duration of the Contract. Locate thermometers at each building floor level after level is enclosed, and also out-of-doors, to obtain representative temperatures.~~

~~2. Record temperatures at noon of each day for each of the thermometer locations as well as the highest and lowest temperatures for the past twenty-four hours, then reset the thermometers.~~

~~B. Weather Log~~

~~1. Maintain a daily weather log with recordings at 8 o'clock a.m., 12 noon and 4 o'clock p.m., including:~~

~~Cloud conditions.~~
~~Precipitation.~~
~~Humidity.~~
~~Temperature.~~
~~Wind velocity and direction.~~
~~Barometric pressure.~~

~~1.10 PROGRESS PHOTOGRAPHS~~

~~A. Photographs~~

~~1. Employ an acceptable qualified, established, commercial photographer to take digital photographs of the Work from locations and at intervals as directed, starting as soon as the Contract is let and as provided in the schedule.~~

~~2. Provide 8 by 10 inch enlargements, each with permanent title block approximately 2-1/2 inches wide by 2 inches high located in the lower right hand corner and containing the following information in neat lettering:~~

~~Owner's name.~~
~~Contract Description and SmithGroup project number.~~
~~Contractor's name.~~
~~Architect's name.~~
~~Photograph number and date.~~
~~Key drawing showing direction from which the individual view was taken.~~

~~B. Schedule~~

~~a. Construction in progress - 4 views per month.~~

~~b. Completed construction - 6 views of interior.~~

~~c. Completed construction - 4 views of exterior.~~

~~d. Completed construction - 2 views of site.~~

~~e. Number of complete sets 4~~

~~1.11~~1.8 POWDER-ACTUATED TOOLS

A. Only low velocity, piston type, powder-actuated tools, as made by Hilti Rapid Fastening Systems, Inc.; Ramset Division, Winchester Arms Corp.; Omark Industries, Inc.; or United Shoe Machinery Co., will be approved.

~~1.12~~1.9 ANCHORAGE TO FLOOR DECK

A. Obtain prior approval for anchorages to underside of metal-deck-supported concrete floor slabs for support of Work other than suspended ceilings, unless such anchorage is indicated.

~~1.13~~1.10 GLASS

A. Glass Protection

1. Exercise precaution for the protection of glass, both existing and glass installed under the Contract. Until the building is occupied and accepted by Owner, be responsible for the replacement of broken, scratched, or otherwise damaged glass with like material.

B. Glass Cleaning

1. Immediately before turning completed Work over to the Owner, have both sides of installed interior and exterior glass cleaned by professional window washers, except for glass cleaning as specified in a particular trade Section.

END OF SECTION

SECTION 016000
PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Products
2. Manufacturer's Instructions
3. Product Options
4. Substitutions
5. Transportation and Handling
6. Storage and Protection

B. Related Sections

1. Section 013300 - Submittals, Shop Drawings, Product Data and Samples
2. Section 018300 - Operating and Maintenance Data

1.2 SYSTEM DESCRIPTION

A. Manufacturer's Instructions

1. When Contract Documents require work to comply with manufacturer's instructions, obtain and distribute copies in accordance with Shop Drawings.
2. Handle, install, connect, clean, condition and adjust products in accordance with such instructions and specified requirements. If conflict occurs between manufacturer's instructions and Contract Documents, do not proceed until consulting with Owner and instructions are clear.

B. Product Options

1. Within 30 days after contract award, submit to Owner a complete list of major products proposed to be used with the name of the manufacturer and installing subcontractor.
2. Contractor's options for selection include the following:
   a. For products specified only by reference standard, select any meeting that standard which comply with specifications and intended usage.
   b. For products specified by naming several products or manufacturers, select any one of the products or manufacturers named which comply with the specifications and intended usage.
   c. For products specified by naming only one product and manufacturer, there is no option except as described under Substitutions.

C. Substitutions

1. For a period of 30 days after contract award, the Owner will consider written requests from the contractor for substitution of products.
2. Submit a separate request for each product, supported with complete data, drawings and samples as appropriate. Information shall include:
   a. Comparison of the qualities of the proposed substitution with that specified
   b. Changes required in other elements of the work because of the substitution

c. Effect on the construction schedule

d. Cost data comparing the proposed product with that specified

e. Source of replacement materials

3. Contractor shall waive claims for additional costs, under his responsibility, which may subsequently become apparent.

4. The Owner will review requests for substitutions with reasonable promptness and notify the contractor in writing.

5. Substitutions will not be considered when they are indicated or implied on shop drawings or product data submittals without a separate written request or when acceptance will require substantial revision of Contract Documents.

1.3 QUALITY ASSURANCE

A. Material and equipment incorporated into the work shall conform to applicable specifications and comply with size, make, type and quality specified or as specifically approved by the Owner.

B. Manufactured and fabricated products shall be designed, fabricated and assembled in accord with the best engineering and shop practices. Manufacture of duplicate units shall be built to standard sizes and gages, be interchangeable and by the same manufacturer.

C. Products shall be suitable for service conditions.

D. Products or materials shall not be manufactured in whole or in part of asbestos, lead, or other material which would be hazardous in its final state, unless specifically listed in another section of these specifications.

E. Equipment capacities, sizes and dimensions shown or specified shall be adhered to unless variations are specifically approved.

F. Do not use material or equipment for any purpose other than that for which it is designed or specified.

1.4 DELIVERY, STORAGE, AND PROTECTION

A. Transportation and Handling

1. Arrange deliveries of products and equipment in accordance with construction schedules and coordinate to avoid conflict with work and site conditions.

2. Deliver products in undamaged condition and immediately upon delivery inspect shipments to assure compliance with requirements of Contract Documents and approved submittals.

3. Provide equipment and personnel to handle products by methods to prevent soiling and damage.

B. Storage and Protection

1. Store products in accord with manufacturer's instructions and maintain temperature and humidity ranges as recommended.

2. For exterior storage, products are to be above ground on blocking or skids. Those subject to deterioration are to be covered with impervious sheet coverings and adequately ventilated to avoid condensation.

3. Inspect periodically to assure products are maintained under specified conditions and free of damage or deterioration.

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PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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SECTION 017350
CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Contractor shall be responsible for all cutting, fitting and patching, including attendant excavation and backfill, required to complete the work or to:

   a. Make its several parts fit together properly.

   b. Uncover portion of the work to provide for installation of ill-timed work.

   c. Remove and replace defective work.

   d. Remove and replace work not conforming to requirements of Contract Documents.

   e. Remove samples of installed work as specified for testing.

   f. Provide routine penetrations of nonstructural surfaces for installation of piping and electrical conduit.

B. Related Sections

1. Section 011100 - Summary of Work

2. Section 016000 - Product Requirements

1.2 SUBMITTALS

A. Submit a written request to Owners Representative well in advance of executing any cutting or alteration which affects the work of the Owner or any separate contractor, structural value, integrity of any element of the Project, integrity or effectiveness of weather-exposed or moisture-resistant elements or systems, efficiency, operational life, maintenance or safety of operational elements, and visual qualities of sight-exposed elements.

B. Request shall include:

1. Identification of the project, description of the affected work and the necessity for cutting, alteration or excavation. The effect on work of any separate contractor or on structural or weatherproof integrity of project.

2. Description of proposed work shall include the scope of cutting, patching, alteration, or excavation, trades who will execute the work, products proposed to be used and the extent of refinishing to be done. Also included shall be alternatives to cutting and patching, cost proposal, when applicable and written permission of any separate contractor whose work will be affected.

3. Should conditions of the work or the schedule indicate a change of products from the original installation, Contractor shall submit a request for substitution as specified in Section 016000 - Product Requirements.

4. Submit a written notice to Owners Representative designating the date and the time the work will be uncovered.

1.3 QUALITY ASSURANCE

A. All work and material shall comply with industry standards.

B. Perform all cutting and patching in strict accordance with pertinent requirements of the Specifications and, in the event no such requirements are determined, in conformance with the Owner's written direction.

1. Use skilled workmen to perform all cutting and patching work.
2. Use methods least likely to damage existing surfaces and materials to remain, while providing proper surfaces to receive installation of repair, patching, and/or new work.

C. Visual Quality

1. Do not cut and patch work exposed to public view, and the exterior and/or interior of the building in a manner that will result in an unacceptable appearance as determined by the Owner.
2. Do not cut and patch work in a manner that will result in obvious appearance that cutting and patching work was done.
3. When cutting existing concrete, do not extend saw cuts beyond the corners of the required opening on either side of the opening.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with specifications and standards for each specific product involved.

B. Use materials which are identical to existing materials in workmanship, appearance, and performance unless otherwise indicated in the Specifications or by the Owner.

C. If identical materials are not available, match existing as closely as possible, especially existing visual characteristics.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect existing conditions of the project, including elements subject to damage or to movement during cutting and patching.

B. After uncovering work, inspect the conditions affecting the installation of products, or performance of the work.

C. Report unsatisfactory or questionable conditions to the Owners Representative in writing; do not proceed with the work until the Owners Representative has provided further instructions.

3.2 PREPARATION

A. Provide adequate temporary support as necessary to assure the structural value or integrity of the affected portion of the work.

B. Provide devices and methods to protect other portions of the project from damage.

C. Provide protection from the elements for that portion of the project which may be exposed by cutting and patching work, and maintain excavations free from water.

3.3 ERECTION INSTALLATION APPLICATION

A. Execute cutting and demolition by methods which will prevent damage to other work and will provide proper surfaces to receive installation of repairs.

B. Contain and dispose of offsite, water generated through use of water-jet cutters or other wet sawing equipment.

C. Execute excavating and backfilling by methods which will prevent settlement or damage to other work.

D. Execute fitting and adjustment of products to provide a finished installation to comply with specified products, functions, tolerances, and finishes.

E. Restore work which has been cut or removed; install new products to provide completed work in accordance with requirements of Contract Documents.

F. Fit work airtight to pipes, sleeves, ducts, conduit and other penetrations through surfaces.

G. Refinish entire surfaces as necessary to provide an even finish to match adjacent finishes.

1. Continuous surfaces - refinish to nearest intersection.
2. Assembly - refinish the entire unit.

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SECTION 017400
CLEANING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Throughout the construction period, maintain the buildings and site in a standard of cleanliness as described in this Section.
2. Each phase of Work shall be subject to these requirements prior to Owner acceptance.

B. Related Sections

1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary conditions, and Sections in Division 1 of these Specifications.
2. In addition to standards described in this Section, comply with requirements for cleaning as described in pertinent other Sections of these Specifications.

1.2 QUALITY ASSURANCE

A. Conduct daily inspection, and more often if necessary, to verify that requirements for cleanliness are being met.

B. In addition to these standards described in this Section, comply with pertinent requirements of governmental agencies having jurisdiction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide required personnel, equipment, and materials needed to maintain the specified standards of cleanliness.

B. Use only the cleaning materials and equipment which are compatible with the surface being cleaned, as recommended by the manufacturer of the material.

PART 3 - EXECUTION

3.1 CLEANING

A. Progress Cleaning

1. General
   a. Retain stored items in an orderly arrangement allowing maximum access, not impeding traffic or drainage, and providing required protection of materials.
   b. Do not allow accumulation of scrap, debris, waste material, and other items not required for construction of this Work.
   c. At least twice each month, and more often if necessary, completely remove all scrap, debris, and waste material from the job site.
   d. Provide adequate storage for all items awaiting removal from the job site, observing requirements for fire protection of the ecology.
2. Site

a. Daily, and more often if necessary, inspect the site and pick up all scrap, debris, and waste material. Remove such items to the place designated for their storage.

b. Weekly, and more often if necessary, inspect all arrangements of materials stored on the site. Restack, tidy, or otherwise service arrangements to meet the requirements of subparagraph 3.1 above.

c. Maintain the site in a neat and orderly condition at all times.

3. Structures:

a. Weekly, and more often if necessary, inspect the structures and pick up all scrap, debris, and waste material. Remove such items to the place designated for their storage.

b. Weekly, and more often if necessary, sweep interior spaces clean.

1) "Clean," for the purpose of this subparagraph, shall be interpreted as meaning free from dust and other material capable of being removed by use of reasonable effort and a hand-held broom.

c. As required preparatory to installation of succeeding materials, clean the structures or pertinent portions thereof to the degree of cleanliness recommended by the manufacturer of the succeeding material, using equipment and materials required to achieve the necessary cleanliness.

d. ~~Following the installation of finish floor materials, c~~Clean the finish floor daily (and more often if necessary) at all times while work is being performed in the space in which finished materials are installed.

1) "Clean," for the purpose of this subparagraph, shall be interpreted as meaning free from foreign materials which, in the opinion of the Owner, may be injurious to the finish floor material.

B. Final Cleaning

1. "Clean," for the purpose of this Article, and except as may be specifically provided otherwise, shall be interpreted as meaning the level of cleanliness generally provided by skilled cleaners using commercial quality building maintenance equipment and materials.

2. Prior to completion of the Work, remove from the job site all tools, surplus materials, equipment, scrap, debris, and waste. Conduct final progress cleaning as described in "Progress Cleaning" above.

3. Site

a. Unless otherwise specifically directed by the Owner, broom clean paved areas on the site and public paved areas adjacent to the site.

b. Completely remove resultant debris.

4. Structures

a. Exterior

1) Visually inspect exterior surface and remove all traces of soil, waste materials, smudges, and other foreign matter.

2) Remove all traces of splashed materials from adjacent surfaces.

3) If necessary to achieve a uniform degree of cleanliness, hose down the exterior of the structure.

4) In the event of stubborn stains not removable with water, the Owner may require light sandblasting or other cleaning at no additional cost to the Owner.

b. Interior

1) Visually inspect interior surfaces and remove all traces of soil, waste materials, smudges, and other foreign matter.

2) Remove all traces of splashed material from adjacent materials.

3) Remove paint droppings, spots, stains, and dirt from finished surfaces.

c. Glass

1) Clean inside and outside.

d. Polished surfaces

1) To surfaces requiring routine application of buffed polish, apply the polish recommended by the manufacturer of the material being polished.

5. Schedule final cleaning as approved by the Owner to enable the Owner to accept a completely clean Work Area.

C. Cleaning During Owner's Occupancy

1. Should the Owner occupy the Work Area or any portion thereof prior to its completion by the Contractor and acceptance by the Owner, responsibilities for interim and final cleaning shall be as determined by the Owner in accordance with the General Conditions of the Contract.

END OF SECTION

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SECTION 017500
STARTING OF SYSTEMS

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Testing and Balancing Systems

1. Specific requirements and procedures for starting of systems, testing, adjusting and balancing, and demonstration of systems are included in the Technical Specification Divisions where the system is specified except as follows:

~~a.Equipment: Division 11~~

~~b.~~a. Mechanical Systems: Division~~s 22 and~~ 23

~~c.~~b. Electrical Systems: Division 26

2. Do not place systems into operation until all components are complete and in place, all testing and inspection has been performed and authorization of Owner has been received.

B. System Demonstrations

1. Fully demonstrate and instruct Owner's maintenance personnel on all operations and maintenance of all equipment and controls as a condition to final acceptance.

1.2 SUBMITTALS

A. Provide four (4) copies of all Operating Instructions and Maintenance Manuals 7 days prior to systems demonstrations.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 017700
PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide an orderly and efficient transfer of the completed Work to the Owner.

B. Related Sections

1. Documents affecting work of this Section include, but are not necessarily limited to, General Requirements, Supplementary conditions, and Sections in Division 1 of these Specifications.

1.2 SYSTEM DESCRIPTION

A. Substantial Completion

1. Notify owner of completion in writing and request punch list inspection.
2. Submit materials specified in 013300, A-8 Contract Closeout Submittal.
3. Within a reasonable time after notification, the Owner and Contractor shall inspect the work, prepare a punch list and determine the status of completion.
4. Should the Owner determine that the Work is not substantially complete:
   a. The Owner promptly will notify the Contractor, in writing, giving the reasons.
   b. Contractor shall remedy the deficiencies and notify the Owner in writing when ready for reinspection.
   c. The Owner will reinspect the Work.
5. When the Owner concurs that the Work is substantially complete:
   a. The Owner will prepare a "Certificate of Substantial Completion", accompanied by the contractor's list of items to be completed and schedule of completion as verified by the Project Manager.

B. Final Completion

1. Prepare and submit the notice required by the General Requirements.
2. Verify that the Work is complete including, but not limited to, the items mentioned in Section 013300, A-8, Contract Closeout Submittal.
3. Certify that:
   a. Contract Documents have been reviewed.
   b. Work has been inspected for compliance with the Contract Documents.
   c. Work has been completed in accordance with Contract Documents.
   d. Equipment and systems have been tested as required, and are operational.
   e. Work is completed and ready for final inspection.
4. The Owner will make an inspection to verify status of completion.
5. Should the Owner determine that the Work is incomplete or defective:
   a. The Owner promptly will so notify the Contractor in writing, listing the incomplete or defective work.

b. Contractor shall remedy the deficiencies promptly, and notify the Owner when ready for reinspection.

6. When the Owner determines that the Work is acceptable under the Contract Documents, he will request the Contractor to make closeout submittals.

C. Final adjustment of accounts

1. Submit a final statement of accounting to Owner, showing all adjustments to the Contract Sum.
2. If so required, the Owner will prepare a final Change Order showing adjustments to the Contract Sum, which were not made previously by Change Order.

D. Instruction

1. Instruct the Owner's personnel in proper operation and maintenance of systems, equipment, and similar items which were provided as part of the Work.

1.3 SUBMITTALS

A. Closeout submittals include, but are not necessarily limited to:

1. Project Record Documents described in Section 013300;
2. Operation and maintenance data for items so listed in pertinent other Sections of these Specifications, and for other items when so directed by the Owner;
3. Warranties and bonds;
4. Keys and keying schedule;
5. Spare parts and materials extra stock;
6. Certificates of Inspection for products and completed operations;
7. Evidence of payment and release of liens;
8. List of subcontractors, service organizations, and principal vendors, including names, addresses, and telephone numbers where they can be reached for emergency service at all times including nights, weekends, and holidays.

1.4 QUALITY ASSURANCE

A. Prior to requesting inspection by the Owner, use adequate means to insure that the Work is completed in accordance with the specified requirements and is ready for the requested inspection.

1.5 WARRANTY

A. The Contractor and each subcontractor shall remedy any defects due to faulty materials or workmanship and pay for any damage to other work resulting there from which shall appear in his work within a period of one year from the date of Notice of Acceptance and in accordance with the terms of any special warranties provided in the contract. The Owner shall give notice of observed defects with reasonable promptness.

B. Upon completion of the work, the Contractor shall deliver to the Owner, in duplicate, a written warranty based on the provision of this Article properly signed and notarized. Warranty shall be addressed to the Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 017800
PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Maintain at the site for the Owner one record copy of all drawings, specifications, addenda, change orders and other modifications to the contract, approved shop drawings, product data and samples. Also include all field test records, installation instructions, operating and maintenance data and warranties and bonds.

2. Recording

   a. Label each document "PROJECT RECORD" in neat, large printed letters. Record information concurrently with construction progress. Do not conceal work until required information is recorded.

   b. As-Built Drawings shall be legibly marked to record actual construction with heights of various elements in relation to finished floor elevation datum. Horizontal and vertical locations of underground utilities and appurtenances shall be referenced to permanent surface improvement. Location of internal utilities and appurtenances concealed in the construction shall be referenced to visible and accessible features of the structure. Drawings shall also include field changes of dimension and detail, changes made by Field Order or by Change Order and details not on original Contract drawings.

   c. Specifications and addenda shall be legibly marked in each Section to record the manufacturer, trade name, catalog number and supplier of each product and item of equipment actually installed and any changes made by Change Order.

   d. Drawings and specifications –of post addenda items, whether written or drawn, shall be placed on the pages affected such that all cut-outs of items are securely attached to the sheet which the addenda modified, along with the addenda number being reflected in each posted item. Completely revised sheets are posted over the sheet revised and the outdated sheet is labeled "VOID".

   e. As-built drawings are to be updated on a continual basis, as the Work is being performed. Owner review of As-built drawings shall be done on a weekly basis

   f. Operating and maintenance data, warranties and bonds shall be submitted as required by Section 017300 and the terms and conditions of this contract.

3. Related requirements in other parts of the project manual shall include conditions of the contract.

B. Related Sections

1. Section 013300 - Shop Drawings

2. Section 018300 - Operating and Maintenance Data

1.2 SUBMITTALS

A. At Contract closeout, deliver Record Documents to Owners Representative for the Owner with electronic copies of final mark-ups of specifications and drawings.

B. Accompany submittal with transmittal letter in duplicate, containing the date, project title and number, Contractors name and address, title and number of each Record Document and the signature of Contractor or his authorized representative.

1.3 MAINTENANCE

A. Store documents and samples in Contractor's field office apart from documents used for construction. Provide files and racks for storage of documents. Provide locked cabinet or secure storage space for storage of samples.

B. Maintain documents in a clean, dry, legible condition and in good order. Do not use record documents for construction purposes.

C. Make documents and samples available at all times for inspection by Owners Representative.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 018113
SUSTAINABLE DESIGN REQUIREMENTS

PART 1 - GENERAL

1.1 ENVIRONMENTAL REQUIREMENTS FOR THE PROJECT

A. The Owner has established the following environmental requirements for the Project. These requirements are general in nature; refer to specific specification sections for more detailed requirements. Notify Owner and Architect if conflicts arise between performance of the work and environmental requirements. This specification is not intended to limit alternative means of achieving these requirements. Suggestions and input from the contractor(s) for implementing these requirements are encouraged. A team approach is encouraged. Refer to Section 015050 – Construction Waste Management.

1. Use resources efficiently:
   a. Reuse existing buildings and materials.
   b. Select materials that use resources efficiently.
   c. Use construction practices that achieve the most efficient use of resources and materials.
   d. Recycle or reuse job-site waste.
   e. Select recycled-content materials.
   f. Select materials that can be recycled.
2. Avoid scarce, irreplaceable, or endangered resources:
   a. Select materials from abundant, well-managed resources.
   b. Select materials that are replaceable, renewable, or can be replenished.
   c. Select materials that minimize damage to natural habitats.
3. Use durable materials:
   a. Select materials with the longest usable life.
   b. Select materials that can be reused.
   c. Select materials with the least burdensome maintenance requirements.
4. Create spaces that are healthy for occupants:
   a. Select low-toxic products and materials.
   b. Select materials without toxic maintenance requirements.
   c. Specify mechanical equipment that will provide fresh air and will not trap water or pollutants.
5. Use energy efficiently:
   a. Select materials with low embodied energy.
   b. Select materials that save energy during building operations.
   c. Select products and equipment that save energy during building operations.
6. Use water efficiently:
   a. Use construction practices that achieve the most efficient use of water.
   ~~b. Select water-conserving appliances and equipment.~~
   ~~c. Landscape for water conservation.~~

~~d. Detain and utilize rainwater.~~

7. Select materials that generate the least amount of pollution. Consider pollution and toxins generated during harvesting, mining, manufacturing, transport, installation, use and disposal.
8. Protect/restore natural habitats.

1.2 ENVIRONMENTAL REQUIREMENTS IMPLEMENTATION

A. Contractor shall designate an on-site party (or parties) responsible for instructing workers and overseeing the Environmental Requirements for the Project.

B. Distribution: The Contractor shall distribute copies of the Environmental Requirements to the Job-Site Foreman, each Subcontractor, the Owner, and the Architect.

C. Meetings: Environmental Requirements shall be discussed at the following meetings:

1. Pre-bid meeting
2. Pre-construction meeting
3. Regular job-site meetings

1.3 CONTRACTOR OBLIGATIONS

~~A. Contractor to validate required recycled content and local/regional availability within 500 mile radius of project.~~

B. Utilize attached recycle content worksheet to identify materials noted above. See 018113A, Appendix A Materials Used for Recycle Content.

~~C. Refer to attached LEED rating system matrix for project requirements. See 018113B, Appendix B LEED Matrix.~~

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 018113A
APPENDIX A
MATERIALS ANTICIPATED TO BE USED FOR RECYCLED CONTENT

The utilization of building materials with recycled content will be maximized in the construction of this project. The requirements established by Executive Order 13101, with regard to building construction materials will be met or exceeded. A listing of the materials anticipated to be of recycled content is provided below. The materials listed below, not indicating recycled content require the contractor to provide and list as much recycled content as feasible and the contractor may list additional materials to be considered/utilized with the recycled content and local/regional availability in the chart below to validate required recycled content and local/regional availability within 500 miles of project site.

	Specification	Recycle Content	Local/Regional Material
Division 2			
Division 3			
Division 4			
Division 5			
Division 6			
Division 7			
Division 8			
Division 9			
Division 10			
Division 11			

END OF SECTION

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SECTION 018300
OPERATING AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Compile product data and related information appropriate for Owner's maintenance and operation of products furnished under the contract.
2. Prepare operating and maintenance data as specified in this section and as referenced in other pertinent sections.

B. Related Sections

1. Section 013300 - Submittals, Shop Drawings, Product Data and Samples
2. Section 017800 - Project Record Documents

1.2 SUBMITTALS

A. Form of Submittals

1. Prepare in the form of an instructional manual for use by Owner's personnel.
2. Format shall be 8-1/2" X 11".
3. Drawings shall be provided with reinforced punched binder tabs and bound in with text. Fold larger drawings to the size of the text pages.
4. Provide flyleaf for each separate product or each piece of operating equipment with typed description of product and major component parts. Provide indexed tabs.
5. Cover shall include title of project, identification of separate structures and identity of general subject matter contained within. Provide printed title stating "OPERATING AND MAINTENANCE MANUAL".
6. Binders shall be commercial quality three-ring with durable plastic covers, maximum ring size of 1-1/2".

B. Content of Manual (Provide electronic product)

1. Provide table of contents for each volume stating:
   a. Contractor
   b. Name of responsible principal, address and telephone number
   c. Indexed list of each product with:
      1) Specification Section
      2) Name of the installer
      3) Manufacturer
      4) Local source of supply
2. Product data sheets to be only those pertinent to the project and shall be clearly identified for the particular part installed.
3. Provide supplement drawings as necessary to clearly illustrate the product data, relations to equipment and systems, and control diagrams. Do not use Project Record Documents as maintenance drawings, but coordinate to assure correct illustration of completed installation.

4. Incorporate a copy of each warranty, bond and service contract issued. Attach information sheet to identify procedures in the event of failure and instances that might affect the validity of warranties or bonds.

C. Manual for Materials and Finishes

1. Content for the architectural products, applied materials and finishes shall include the following:
   a. Manufacturer's data:
      1) Catalog number
      2) Size
      3) Composition
      4) Color designations
      5) Texture designations
      6) Information required for reordering special manufactured products.
   b. Manufacturer's recommendations and cautions for cleaning agents and methods.
   c. Manufacturer's data for moisture protection and weather exposure:
      1) Applicable standards
      2) Chemical composition
      3) Details of installation.
   d. Instructions for maintenance and repair.

D. Submittal Schedule

1. Submit two copies of preliminary draft of proposed formats and completed data fifteen days prior to final inspection or acceptance. Owner shall review and return one copy with comments.
2. Submit three compact disc copies of approved data in final form fifteen days after final inspection.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 024119
SELECTIVE STRUCTURE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Demolition of buildings or portions of buildings.
2. Sub grade removal including:
   a. Foundations
   b. Floor slab demolition
   c. Underground tanks and piping
3. Disconnection, capping, and identification of utilities.
4. Removal of materials from site.
5. Salvage.

B. Related Sections

1. Section 01735 - Cutting and Patching

1.2 SUBMITTALS

A. Submit demolition and removal procedures and schedule under provisions of Section 01330.

B. Submit record documents under provisions of Section 01770.

1.3 PROJECT/SITE CONDITIONS

A. Existing Conditions and Occupancy

1. Areas immediately adjacent to areas designated for demolition may be occupied by NREL personnel.
2. Conduct selective demolition work in a manner that will minimize the need for disruption of normal operations and as specified in Division 1, General Requirements.
3. A minimum of 72 hours advance notice of demolition activities and utility outages is required.

B. Environmental Controls

1. Pollution Controls
2. Comply with all governing regulations.
3. Return areas to condition existing prior to start of work.
4. Keep dust and dirt from entering existing facilities and occupied areas.
5. Coordinate noisy operations and vibration creating operations with Owner such that nearby functioning facilities and occupied areas are disturbed minimally.
6. Use water sprinkling, temporary enclosures, and other suitable methods to limit dust and dirt rising and scattering in air to lowest practical level.
7. Use of explosives will not be permitted.
8. Traffic

a. Ensure minimum interference with roads, streets, walks, and adjacent occupied or used facilities.

b. Provide alternate routes around closed or obstructed vehicular and pedestrian roads and walks as required by governing regulations.

9. Utilities

a. Before disconnecting, removing, plugging or abandoning any existing utilities:

1) Notify the Owner, applicable utility companies, and local authorities have jurisdiction.

2) Remove, cut off and plug, or cap all utilities within the existing building areas to be demolished, except those designated to remain.

b. Locate and protect existing utilities to remain during demolition operations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Owner will identify salvageable items. As the salvaged items are removed, they will be transported to a location determined by the Owner.

B. All other items removed shall be transported out of the construction area in a timely manner.

PART 3 - EXECUTION

3.1 EXAMINATION

A. NREL will identify any known hazardous material involved in the demolition.

B. Contractor shall notify the Owner's Representative before proceeding further if materials are encountered that is suspected of being hazardous. A hazardous materials survey will be performed by NREL after notification by Contractor.

3.2 PREPARATION

A. Provide interior and exterior shoring, bracing, or support.

B. Cover and protect furniture, equipment and fixtures.

C. Erect and maintain dust-proof and weatherproof partitions and closures as required.

D. Locate, identify, stub-off and disconnect utility services that are indicated to be removed.

3.3 ERECTION INSTALLATION APPLICATION

A. Demolition

1. Perform demolition work in a systematic manner.Demolish concrete and masonry in small sections. Cut concrete and masonry using power-driven masonry saw or hand tools. Do not use power-driven impact tools inside buildings.

2. Locate demolition equipment throughout structure to avoid imposing excessive loads on supporting walls, floors or framing.

3. Do not cut or alter any structural member without authorization of Owner and/or Architect.

B. Buried Tanks

1. Buried tanks that are to be removed shall be pumped out. Comply with EPA and State of Colorado requirements regarding equipment and disposal of tank contents.
2. Per Owner direction underground tanks will be filled with clean sand or lean concrete or will be removed.

C. Disposal

1. Remove debris, rubbish and other materials resulting from demolition operations from building site and off Owner's property.
2. NREL dumpsters shall not be used for disposal of demolished materials.
3. Transporting and disposal of materials off site shall be done in a legal manner.
4. Burning of removed materials will not be permitted on the site.
5. Hazardous or otherwise regulated waste materials will be disposed of in compliance with all applicable local, state and federal regulations, and must be coordinated with Owner.

END OF SECTION

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SECTION 072100
THERMAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Furnishing and installation of mineral or glass fiber insulation in the walls indicated on the Drawings, and rigid insulation required for roof and foundation walls.

B. Related Sections

1. Section 054000 - Cold formed metal framing
2. Section 075300 - Elastomeric Membrane Roofing
3. Section 092900 - Gypsum Board System

1.2 SUBMITTALS

A. Comply with all pertinent provisions of Section 013300.

B. Provide product data for all products to be utilized.

C. Submit manufacturer's catalog data, performance information, and published certification data indicating compliance with the specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Mineral or Glass Fiber Insulation Batt

1. FS HH-I-421E, Type I.
2. Foil faced.
3. 1.7 lb. minimum density.
4. K-value of 0.27 flexible blanket with reflective vapor barrier.
5. Provide in locations, R valves and/or thicknesses as indicated.
6. Apply where indicated, as recommended by manufacturer.

B. Loose Fill Fiber Glass Insulation

1. “Optima” System by Certain Teed Corp., or approved equal
2. Unbonded, white, loose-fill virgin fiber glass, for pneumatic application
3. Closed cavity sidewall installation
4. R=23 for 6’ wall
5. Density= 1.8 pcf
6. Apply where indicated, as recommended by manufacturer

C. Roof Insulation

1. 5 1/2" expanded polystyrene- Type II
2. R=4.4 per inch at 40^0 F; 4.0 per/inch at 75^0 F

3. Compressive strength= 15psi (min).
4. Density= 1.35 pcf
5. With 1/2" protection board (composite).

D. Foundation Walls

1. 2" expanded polystyrene (EPS).
2. R=8.33.

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. Install insulation as recommended by manufacturer.

B. Insulation shall be continuous, without voids or interruptions, and on cold side of pipes.

C. Install with vapor barrier on conditioned side of insulation.

D. The method of installing insulation is the Contractor's choice.

1. The insulation, when installed shall be secure and stable.
2. The use of combustible adhesives is prohibited.

E. See drawings for miscellaneous insulation requirements.

F. Where not specifically called out fill available space with maximum R-value insulation.

G. All exterior/interior separation shall be insulated.

3.2 SCHEDULES

A. Insulation Schedule

1. Location Receiving Construction
   a. Thickness & R-Value
   b. (R-Value takes precedence over thickness)
2. Frame cavity, at building exterior: 6" loose fill, R=23; Batts R=19
3. Interior partitions (sound insulation): 3 1/2" acoustic blanket

END OF SECTION

SECTION 078413
FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Firestopping shall consist of furnishing and installing a material or a combination of materials to form an effective barrier at penetrations in fire resistance-rated walls, horizontal assemblies and smoke barriers against the spread of flame, smoke, and gases, and to maintain the integrity of fire-rated construction.
2. Firestopping shall be provided in the following locations:
    a. Duct, conduit, and pipe penetrations through above grade floor slabs and through fire-rated walls.
    b. Cracks, voids, and holes in fire-rated walls, ceilings, and floors.
    c. Other locations specifically designated on the drawings.

B. Related Sections

1. Section 092900 - Gypsum Board System
2. Divisions 22 and 23 - Mechanical Work
3. Division 26 - Electrical Work

1.2 REFERENCES

A. Firestopping materials shall consist of commercially manufactured products complying with the following minimum requirements:

1. Flame Spread: Twenty-five or less when tested in accordance with ASTM E84
2. Smoke Density: Fifty or less when tested in accordance with ASTM E84
3. Fuel Contribution: Twenty-five or less when tested in accordance with ASTM E84
4. Nontoxicity: Nontoxic to human beings at all stages of application and during fire conditions

B. Materials used to seal penetrations in fire-rated assemblies shall be capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to ASTM E119 time-temperature conditions for a period of time at least equal to the fire resistant rating of the fire-rated assembly.

1.3 SUBMITTALS

A. Comply with all pertinent provisions of Section 013300.

B. Provide product data for all products to be utilized as designated in manufacturer’s UL detail and material description.

C. Submit manufacturer's product data, UL Listing/Detail for proposed product, and installation instructions for each condition requiring firestopping. Include data substantiating that materials comply with specified requirements and/or are proper for the particular applications.

1.4 DELIVERY, STORAGE, AND PROTECTION

A. Do not install firestopping materials under adverse weather conditions and when temperatures are below or above manufacturer's recommended limitations for installation.

B. Materials shall be delivered in the original unopened packages or containers showing name of the manufacturer and the brand name.

C. Materials shall be protected from damage and exposure to elements.

D. Damaged or deteriorated materials shall be removed from the site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M Products

B. Dow Corning Corporation

C. United States Gypsum

D. Grace Construction Products

E. Hilti, Inc.

2.2 MATERIALS

A. Provide penetration firestopping that is 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. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.

B. Penetrations in Fire-Resistance-Rated Walls: Ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg (2.49 Pa).

1. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

C. Penetrations in Horizontal Assemblies: Ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg (2.49 Pa).

1. F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.

2. T-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.

D. Penetrations in Smoke Barriers: Provide penetration firestopping with ratings determined per UL 1479.

1. L-Rating: Not exceeding 5.0 cfm/sq. ft. (0.025 cu. m/s per sq. m) of penetration opening at 0.30-inch wg (74.7 Pa) at both ambient and elevated temperatures.

E. Exposed Penetration Firestopping: Provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

F. VOC Content: Provide penetration firestopping that complies with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Architectural Sealants: 250 g/L.

2. Sealant Primers for Nonporous Substrates: 250 g/L.

3. Sealant Primers for Porous Substrates: 775 g/L.

G. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping manufacturer and approved by qualified testing and inspecting agency for firestopping indicated.

H. Firestopping materials shall be compatible with adjacent materials so that no adverse effects will occur as a result of contact with these materials.

2.3 NREL STANDARD ASSEMBLIES

A. At gypsum board/stud wall assemblies, provide 3M Fire Barrier Pass-Through Device (https://multimedia.3m.com/mws/media/446190O/3m-fire-barrier-pass-through-technical-data-sheet.pdf) and the Metacaulk Pass-Through Device (http://metacaulk.com/fsgdata/Datasheet/data_pass_thru.pdf). As appropriate, utilize UL Design W-L-8089, which provides for a range of metallic and non-metallic penetrants, including various wires and cables for the Metacaulk product. Or, utilize UL Design W-L-8069 for the 3M Fire Barrier Pass-Through Device. Specify square (2.5 inch and 4 inch) or round devices (2 inch and 4 inch). Provide top hinge to facilitate installation in existing openings and to assist with later removal and replacement of penetrants. Provide foam seal that is intended to center penetrating items in the opening. Note that the 3M product tends to allow larger metallic pipe/tubing penetrants.

B. Using the list of identified penetrants above, the following is allowed outright by UL Design W-L-8069 for the 3M Fire Barrier Pass-Through Device:

1. Blank openings
2. Metal tubing
3. Metal piping
4. Plastic piping
5. Electrical metallic tubing (EMT)
6. Flexible electrical metallic tubing (identified as flexible metal piping)
7. Flexible electrical non-metallic tubing (ENT)
8. Wires and cables [note that power cabling is comparable to Item 2.C22 of UL Design W-L-8069 in outside diameter, overall size, size of conductors, etc.]

C. NREL Standard wall and floor assemblies at labs requires a one hour fire barrier minimum, unless an adjacent building component requires a higher rated assembly.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate the work with other trades.

B. Surfaces to be in contact with firestopping materials shall be free of dirt, grease, oils, loose materials or other substances that may affect proper fitting or the required fire resistance.

3.2 ERECTION INSTALLATION APPLICATION

A. Provide firestopping in the following locations:

1. Duct, cable, conduit and piping penetrations through fire rated partitions.
2. Intersection of roof structure and fire rated wall.
3. Other locations indicated or required.

D. Install forming 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.

F. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestopping.

1. Install fill materials for firestopping by proven techniques to produce the following results:
2. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
3. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.

G. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.3 FIELD QUALITY CONTROL

A. All applications will be inspected to insure proper installation prior to concealing or enclosing the firestopped areas.

3.4 CLEANING

A. After completion of firestopping work in any area, equipment shall be removed and walls, ceilings and all other surfaces not to receive firestopping shall be cleaned of deposits of fire stopping materials.

END OF SECTION

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SECTION 078446
FIRE-RESISTIVE JOINT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes fire-resistive joint systems for the following:

1. Floor-to-floor joints.
2. Floor-to-wall joints.
3. Head-of-wall joints.
4. Wall-to-wall joints.
5. Joints between perimeter edge of fire-resistance-rated floor assemblies and back of non-fire-resistance-rated, exterior, glazed aluminum curtain walls.

1.2 REFERENCES

A. International Conference of Building Officials (ICBO)

1. Evaluation Service

a. AC30 – Joint Systems.

B. Uniform Building Code (UBC)

1. Standard 26-9 – Method of Test for the Evaluation of Flammability Characteristics of Exterior, Nonload-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus.

C. Underwriters Laboratories Inc. (UL)

1. 2079 – Tests for Fire Resistance of Building Joint Systems.
2. Fire Resistance Directory

1.3 PERFORMANCE REQUIREMENTS

A. General: For joints in the following constructions, provide fire-resistive joint 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 assembly in which fire-resistive joint systems are installed:

1. Fire-resistance-rated load-bearing walls, including partitions, with fire rated openings.
2. Fire-resistance-rated non-load-bearing walls, including partitions, with fire rated openings.
3. Fire-resistance-rated floor assemblies.
4. Exterior curtain-wall assemblies and fire-resistance-rated floor assemblies.

B. Fire Resistance of Joint Systems: Assembly ratings indicated, but with assembly ratings not less than that equaling or exceeding fire-resistance rating of constructions in which joints are located, as determined by UL 2079.

1. Load-bearing capabilities as determined by evaluation during the time test.

C. Fire Resistance of Perimeter Fire-Containment Systems: Integrity and insulation ratings indicated as determined by UBC Standard 26-9 and/or UL 2079.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each fire-resistive joint system, show each kind of construction condition in which joints are installed and relationships to adjoining construction. Include fire-resistive joint system design designation of testing and inspecting agency acceptable to authorities having jurisdiction that demonstrates compliance with requirements for each condition indicated.

1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each fire-resistive joint system configuration for construction and penetrating items.

C. Product Certificates: For each type of fire-resistive joint system, signed by product manufacturer.

D. Qualification Data: For Installer.

E. Compatibility and Adhesion Test Reports: From fire-resistive joint system manufacturer indicating the following:

1. Materials forming joint substrates have been tested for compatibility and adhesion with fill materials.

2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

F. Research/Evaluation Reports: For each type of fire-resistive joint system.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain fire-resistive joint systems for each kind of joint and construction condition indicated through one source from a single manufacturer.

B. Preconstruction Compatibility and Adhesion Testing: Submit to fire-resistive joint system manufacturers, for testing indicated below, samples of materials that will contact or affect fill materials.

1. Use manufacturer's standard test methods to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of fill materials to joint substrates.

a. Perform tests under environmental conditions replicating those that will exist during installation.

2. Submit no fewer than nine pieces of each type of material, including joint substrates, forming materials, and miscellaneous materials.

3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.

4. For materials failing tests, obtain fire-resistive joint system manufacturer's written instructions for corrective measures, including the use of specially formulated primers.

C. Fire-Test-Response Characteristics: Provide fire-resistive joint systems that comply with the following requirements and those specified in "Performance Requirements" Article:

1. Fire-resistance tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL, Omega Point or another agency performing testing and follow-up inspection services for fire-resistive joint systems acceptable to authorities having jurisdiction.

2. Fire-resistive joint systems are identical to those tested per ICBO ES AC30 and are qualified for types of joints and joint movement capabilities indicated in a current Evaluation Report by the ICBO Evaluation Service.

3. Fire-resistive joint systems are identical to those tested per UL 2079. Provide rated systems complying with the following requirements:
    a. Fire-resistive joint system products bear classification marking of qualified testing and inspecting agency.
    b. Fire-resistive joint systems correspond to those indicated by referencing system designations listed by the following:
        1) UL in its "Fire Resistance Directory."
        2) Omega Point in its “Fire Resistance Directory.”

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fire-resistive joint system products to Project site in original, unopened containers or packages with qualified testing and inspecting agency's classification marking applicable to Project and with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life, curing time, and mixing instructions for multicomponent materials.

B. Store and handle materials for fire-resistive joint systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not install fire-resistive joint systems when ambient or substrate temperatures are outside limits permitted by fire-resistive joint system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate fire-resistive joint systems per manufacturer's written instructions by natural means or, if this is inadequate, forced-air circulation.

1.8 COORDINATION

A. Coordinate construction of joints to ensure that fire-resistive joint systems are installed according to specified requirements.

B. Coordinate sizing of joints to accommodate fire-resistive joint systems.

C. Notify Owner's inspecting agency at least seven days in advance of fire-resistive joint system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up fire-resistive joint system installations that will become concealed behind other construction until Owner's inspecting agency and building inspector, if required by authorities having jurisdiction, have examined each installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Fire-Resistive Joint Systems:
    a. International Protective Coatings Corp.
    b. Johns Manville.
    c. Nelson Firestop Products.

d. Specified Technologies Inc.

e. 3M Fire Protection Products.

f. Tremco, Inc.

2. Perimeter Fire-Containment Systems:

a. International Protective Coatings Corp.

b. Johns Manville.

c. Specified Technologies Inc.

d. 3M Fire Protection Products.

e. USG Corp.

2.2 FIRE-RESISTIVE JOINT SYSTEMS

A. General

1. Provide fire-resistive joint systems that are compatible with joint substrates, under conditions of service and application, as demonstrated by fire-resistive joint system manufacturer based on testing and field experience.

2. Provide components of fire-resistive joint systems, including forming materials, that are needed to install fill materials and to comply with Part 1 "Performance Requirements" Article. Use only components specified by fire-resistive joint system manufacturer and approved by the qualified testing and inspecting agency for systems indicated.

3. Where UL-classified fire-resistive joint systems are indicated, they refer to alphanumeric designations listed in the UL “Fire Resistance Directory" under product Category XHBN.

B. Floor-to-Wall, Fire-Resistive Joint System:

1. UL-Classified Products: FW-D – 1000 Series.

2. Assembly Rating: See code plans.

3. Joint Width: 100 mm (4 inches) maximum

4. Movement Capabilities: Class II – 25 percent compression and/or extension.

C. Head-of-Wall, Fire-Resistive Joint System :

1. UL-Classified Products: HW-D – 0000 Series or 1000 Series

2. Assembly Rating: See code plans.

3. Joint Width: 19 mm (¾ inch) for 0000 Series, 100 mm (4 inches) maximum for 1000 Series.

4. Movement Capabilities: Class II - 33 percent compression and/or extension. for 0000 Series, 12.5 percent compression and/or extension for 1000 Series.

D. Wall-to-Wall, Fire-Resistive Joint System :

1. UL-Classified Products: WW-D – 1000 Series

2. Assembly Rating: See code plans.

3. Joint Width: 100 mm (4 inches) maximum.

4. Movement Capabilities: Class II - 25 percent compression and/or extension.

2.3 PERIMETER FIRE-CONTAINMENT SYSTEMS

A. Where UL-classified perimeter fire-containment systems (or safing insulation) are indicated, they refer to alphanumeric designations listed in the UL "Fire Resistance Directory" under product Category XHDG.

B. Perimeter Fire-Containment System

1. UL-Classified or Omega Point-Classified Products:

a. CW-S 1000 Series (UL)

b. CEJ – 100 Series (Omega Point)

2. Integrity Rating: See code plans.

3. Insulation Rating: 1 hour.

4. Linear Opening Width: 200 mm (8 inches) maximum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for joint configurations, substrates, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Clean joints immediately before installing fire-resistive joint systems to comply with fire-resistive joint system manufacturer's written instructions and the following requirements:

1. Remove from surfaces of joint substrates foreign materials that could interfere with adhesion of fill materials.

2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with fill materials. 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 fire-resistive joint 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 fill materials of fire-resistive joint system 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 fire-resistive joint system materials. Remove tape as soon as possible without disturbing fire-resistive joint system's seal with substrates.

3.3 INSTALLATION

A. General: Install fire-resistive joint systems to comply with Part 1 "Performance Requirements" Article and fire-resistive joint system manufacturer's written installation instructions for products and applications indicated.

B. Install forming/packing/backing materials and other accessories of types required to support fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

C. Install fill materials for fire-resistive joint systems by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings and forming/packing/backing materials as required to achieve fire-resistance ratings indicated.
2. Apply fill materials so they contact and adhere to substrates formed by joints.
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 FIELD QUALITY CONTROL

A. Inspecting Agency: Owner will engage a qualified independent inspecting agency to inspect fire-resistive joint systems and to prepare inspection reports.

1. Inspecting agency will state in each report whether inspected fire-resistive joint systems comply with or deviate from requirements.

B. Proceed with enclosing fire-resistive joint systems with other construction only after inspection reports are issued and inspecting agency has approved installed fire-resistive joint systems.

C. If deficiencies are found, repair or replace fire-resistive joint systems so they comply with requirements.

3.5 CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to joints as Work progresses by methods and with cleaning materials that are approved in writing by fire-resistive joint 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 fire-resistive joint systems are without damage or deterioration at time of Substantial Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated fire-resistive joint systems immediately and install new materials to produce fire-resistive joint systems complying with specified requirements.

END OF SECTION

SECTION 079200
JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Work is to include the sealing of all penetrations and attachments to provide air and water tight integrity, where specified, and the juncture of materials to seal for finishes and overall appearance.

B. Related Sections

1. Section 078413 - Firestopping
2. Section 081113 – Hollow Metal Doors and Frames
3. Section 088000 - Glazing
4. Section 099100 - Painting

1.2 SUBMITTALS

A. Submit manufacturer's catalog data, performance information and published certification data indicating compliance with the specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Joint Fillers and Gaskets

1. Materials to be exactly as recommended by sealant manufacturer as to type of material, size, location for use and any other requirements.
2. Primers:
   a. Exactly as recommended by sealant manufacturer as to type of material, surface to be applied to and any other requirements.

B. Sealants and Caulking

1. Elastomeric Sealant Compounds
   a. 2-component Polysulfide Sealant:
      1) FS TT-S-00230C, Type 2 (non-sag), Class A. Use for all exterior caulking except as indicated.
   b. Acid Type Silicone Sealant:
      1) 1-part, FS TT-S-0991543A, recommended by manufacturer for exterior non-porous joint surfaces. Use for exterior glazing and for caulking storefront components.
   c. Mildew-Resistant Silicone Sealant:
      1) FS TT-S-001543, recommended by manufacturer for use in interior wet areas, acid type, except non-acid type where one or both joint surfaces are porous.
2. Non-Elastomeric Sealant Compounds
   a. I-Component Acrylic Sealant: FS TT-S-00230, Type II, Class B.

1) Use for interior joints between materials not to be painted.

b. Acrylic-Latex Sealant:

1) Emulsion type polymer, permanently flexible, non-staining, non-bleeding.

2) Use for all interior joints to be painted.

C. Colors

1. Colors as shown or selected by Owner; or if none shown or selected, manufacturers highest-performance color.

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. Caulk (seal) all joints as indicated on Drawings.

B. Caulk all joints not indicated, as necessary to weatherproof enclosed spaces.

C. Caulk all joints not otherwise sealed in all finished spaces.

D. Clean joint surfaces and otherwise prepare and prime exactly as recommended by sealant manufacturer.

E. Support sealant from back with joint filler, or with backer rod exactly as recommended by sealant manufacturer.

F. Install sealants to size and shape exactly as recommended by sealant manufacturer.

G. Finish joints as recommended by sealant manufacturer.

H. Consult with Owner and sealant manufacturer in the event of conflicting recommendations.

I. Use only experienced applicators for all of sealant systems.

END OF SECTION

SECTION 081113
HOLLOW METAL DOORS AND FRAMES

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 hollow-metal work.

B. Related Requirements:
   1. Section 087100 "Door Hardware" for door hardware for hollow-metal doors.

1.3 COORDINATION

A. Coordinate anchorage installation 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.

1.4 SUBMITTALS

A. Comply with all pertinent provisions of Section 013300.

B. Product Data: For each type of product.

C. Shop Drawings and Test Reports for each type of hollow metal door and frame assembly, for tests performed by a qualified testing agency.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver hollow-metal work palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.

   1. Provide additional protection to prevent damage to 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 vertically under cover at Project site with head up. Place on minimum 4-inch- (102-mm-) high wood blocking. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ceco Door Products; an Assa Abloy Group company.
   2. Curries Company; an Assa Abloy Group company.
   3. Pioneer Industries, Inc.
   4. Republic Doors and Frames.
   5. Rocky Mountain Metals, Inc.
   6. Steelcraft; an Ingersoll-Rand company.

B. Source Limitations: Obtain hollow-metal work from single source from single manufacturer.

2.2 REGULATORY REQUIREMENTS

A. Fire-Rated Assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings, based on testing at positive pressure according to NFPA 252 or UL 10C.

   1. Smoke- and Draft-Control Assemblies: Provide an assembly with gaskets listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.

B. Fire-Rated, Borrowed-Light Assemblies: Complying with NFPA 80 and 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.

2.3 INTERIOR DOORS AND FRAMES

A. Construct interior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Commercial Doors and Frames: NAAMM-HMMA 861.

   1. Physical Performance: Level A according to SDI A250.4.
   2. Doors:

      a. Type: As indicated in the Door and Frame Schedule.
      b. Thickness: 1-3/4 inches (44.5 mm.)
      c. Face: Uncoated, cold-rolled steel sheet, minimum thickness of 18 gauge,0.0478 inch (1.0 mm).
      d. Edge Construction: Continuously welded with no visible seam.
      e. Core: Steel stiffened.

   3. Frames:

a. Materials: Uncoated steel sheet, minimum thickness of 16 gauge, 0.0598 inch (1.3 mm) for door openings 48 inches (1219 mm) or less, or window frames; minimum thickness of 14 gauge 0.0747 inch (1.7 mm) for door openings greater than 48 inches (1219 mm).
b. Construction: Full profile welded.

4. Exposed Finish: Prime. Clean, pretreat, and apply manufacturer's standard primer.
a. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

2.4 EXTERIOR HOLLOW-METAL DOORS AND FRAMES

A. Construct exterior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Extra-Heavy-Duty Doors and Frames: SDI A250.8, Level 3.

1. Physical Performance: Level A according to SDI A250.4.
2. Doors:

a. Type: As indicated in the Door and Frame Schedule.
b. Thickness: 1-3/4 inches (44.5 mm.)
c. Face: Metallic-coated steel sheet, minimum thickness of 16 gauge, 0.0598 inch (1.3 mm), with minimum A40 (ZF120) coating.
d. Edge Construction: Model 1, Full Flush.
e. Core: Polyisocyanurate.

1) Thermal-Rated Doors: Provide doors fabricated with thermal-resistance value (R-value) of not less than 2.1 deg F x h x sq. ft./Btu (0.370 K x sq. m/W)when tested according to ASTM C 1363.

3. Frames:

a. Materials: Metallic-coated steel sheet, minimum thickness of 16 gauge, 0.0598 inch (1.3 mm), with minimum A40 (ZF120) coating.
b. Construction: Full profile welded.

4. Exposed Finish: Prime. Clean, pretreat, and apply manufacturer's standard primer.
a. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

2.5 MATERIALS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

2.6 FABRICATION

A. Fabricate hollow-metal work to be rigid and free of defects, warp, or buckle.

B. Weld exposed joints continuously, grid, dress, and make smooth, flush and invisible.

C. Metallic filler to conceal manufacturer's defects is not acceptable.

D. 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.

E. Hardware Preparation: Factory prepare hollow-metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to SDI A250.6and templates.

F. Make size allowances for weather-stripping, thresholds and floor finishes

G. Stops and Moldings: Provide stops and moldings around glazed lites and louvers where indicated. Form corners of stops and moldings with mitered hairline joints.

2.7 ACCESSORIES

A. Louvers: Provide louvers for interior doors, where indicated, which comply with SDI 111C, with blades or baffles formed of 0.020-inch- (0.5-mm-) thick, cold-rolled steel sheet set into 0.032-inch- (0.8-mm-) thick steel frame.

B. Grout Guards: Formed from same material as frames, not less than 0.016 inch (0.4 mm) thick.

C. Anchors and Accessories: Use galvanized items for units built into exterior walls, complying with ASTM A153

PART 3 - EXECUTION

3.1 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 SDI A250.11 or NAAMM-HMMA 840 as required by standards specified.

C. Hollow-Metal Doors: Fit hollow-metal doors accurately in frames, within clearances specified below. Shim as necessary. Install fire rated units in accordance with NFPA 80.

D. Install fire rated units in accordance with NFPA 80.

END OF SECTION

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SECTION 081416
FLUSH WOOD DOORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide all wood doors indicated on Drawings and in door schedule.
2. Where indicated, provide glass and glazing and similar items built into wood door construction.

B. Related Sections

1. Section 062000 – Interior Finish Carpentry
2. Section 087100 - Door Hardware
3. Section 099100 - Painting

1.2 SUBMITTALS

A. Comply with all pertinent provisions of Section 013000.

B. Provide product data for all products to be utilized.

C. Provide three letter sized samples for Architect's Approval.

D. Provide manufacturer's product data and shop drawings.

1.3 DELIVERY, STORAGE AND PROTECTION

A. At all times protect doors from all conditions that may cause damage such as warping, discoloration, etc.

1.4 WARRANTY

A. Provide manufacturer's standard lifetime of original installation guarantee, agreeing to replace, refinish and re-install defective doors including doors which have warped or show photographing of construction behind face, as defined by WDMA I.S.1-A and AWI.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Any major manufacturer; Graham 5 Ply Particle or Mineral Core FSC Certified or equal.

2.2 MATERIALS

A. Interior Flush Doors

1. AWI custom grade complying with or exceeding commercial standards and WDMA I.S. 1-A.
2. Fire rated doors: As indicated in door schedule, provide doors complying with NFPA 80, finished to match other doors in same area, and bearing U.L. label.
3. Core:
   a. Any AWI approved solid particleboard core typically.
   b. For fire rated doors, core is U.L. approved for specified rating.
4. Veneer:

a. Plain sliced Red Oak, or White Maple with transparent finish (no heartwood permitted). Verify to match existing.

B. Door Thickness

1. As indicated on Drawings, 1 3/4" thick solid core.
2. Coordinate undercutting of doors, to be compatible with adjacent floor coverings, and manufacturer's guarantee requirements.

PART 3 - EXECUTION

3.1 PREPARATION

A. If hardware cutouts will be provided in factory, coordinate with finish hardware for locations and configuration.

3.2 ERECTION INSTALLATION APPLICATION

A. See Section 062000.

END OF SECTION

SECTION 087100
DOOR HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Providing finish hardware throughout the work as specified herein and as needed for a complete and proper installation.
2. Provide the services of an AHC or DAHC member of the American Society of Architectural Hardware Consultants to:
   a. Be available for consultation with the Architect at no additional cost to the Owner during progress of construction.
   b. Be present at completion of construction, and:
      a. Make minor adjustments as required;
      b. Inspect installation of all finish hardware items;
      c. Report to the Architect on completeness of the installation.
   c. The hardware consultant may be an employee of the supplier.
   d. The extent of the hardware is indicated on the drawings.
   e. The required types of hardware include, but are not necessarily limited to, the following:
      a. Hinges
      b. Lock cylinders and keys
      c. Lock, latch and privacy sets
      d. Exit devices
      e. Closures and coordinators
      f. Weather-stripping. silencers, and seals
      g. Thresholds
      h. Wall/Floor stops
      i. Kick and armor plates

B. Related Sections

1. Section 081113 – Hollow Metal Doors and Frames

1.2 SUBMITTALS

A. Comply with all pertinent provisions of Section 013000.

B. Provide product data for all products to be utilized.

C. Submit manufacturer's technical information for each item of hardware.

1. Include whatever information may be necessary to show compliance with requirements.

D. Submit final and coordinating hardware schedule in manner indicated below.

E. Coordinate hardware with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of hardware.

1. Schedule Content:

a. Organize hardware schedule into "hardware sets" indicating complete designations of every item required for each door or opening. Include the following information:

a. Type, style, function, size, and finish of each hardware item

b. Name and manufacturer of each item

c. Fastenings and other pertinent information

d. Location of hardware set cross-referenced to indications on drawings both on floor plans and in door and frame schedule

e. Mounting locations for hardware

2. Keying Schedule:

a. Submit separate detailed schedule indicating how the Owner's final instructions on keying of locks has been fulfilled.

1.3 QUALITY ASSURANCE

A. Obtain each kind of hardware from only one manufacturer, even though several may be specified as acceptable manufacturers.

B. Supplier:

1. A recognized architectural finish hardware supplier, with warehousing facilities, who has been furnishing hardware in the project vicinity for a period of not less than 2 years, and who employs an experienced architectural hardware consultant who is available during the course of the work, for consultation about project's hardware requirements, to Owner, Owner's Representative, and Contractor.

1.4 PROJECT/SITE CONDITIONS

A. Coordination

1. Coordinate hardware with other work.

2. Tag each item or package separately, with identification related to the final hardware schedule, and include basic installation instructions in the package.

3. Furnish hardware items of proper design for use on doors and frames of the thickness, profile, swing, security, and similar requirements indicated, as necessary for proper installation and function.

4. Deliver individually packaged hardware items at the proper times to the proper locations (shop or project site) for installation.

B. Templates

1. Furnish hardware templates to each fabricator of doors, frames, and other work to be factory-prepared for the installation of hardware.

2. Upon request, check the shop drawings of such other work, to confirm that adequate provisions are made for the proper installation of hardware.

1.5 MAINTENANCE

A. Continued Maintenance Service

1. Approximately six months after the acceptance of hardware in each area, the Installer, accompanied by the representative of the latch and lock manufacturer, shall return to the project and re-adjust every item of hardware to restore proper function of doors and hardware.
2. Consult with and instruct Owner's personnel in recommended additions to the maintenance procedures.
3. Replace hardware items, which have deteriorated or failed due to faulty design, materials, or installation of hardware units.
4. Prepare a written report of current and predictable problems (of substantial nature) in the performance of the hardware.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. For the purpose of establishing product standards the following manufacturers are specified; no substitutions are permitted.

1. Locksets, latches and cylinders to be Sargent only. Lock to accept 7-pin SFIC permanent core;
    a. Lockset: Sargent 10 Line Series; Grade 1; Wrought Iron/Solid Cast L Lever with L Rose Design.
    b. Mortise Locks: Sargent 7800/8200 Series; #72 or 73 Electrical Fail Secure.
    c. Deadbolts: Sargent 487.
    d. Roller Latch with cast strike: Rockwood No. 590 or equal.
    e. US26D, satin chromium finish.
2. Exit Devices and Trim:
    a. Panic Exit Device and Trim: Von Duprin Commercial Grade EL 98 Series; Touch Bar with 06 Lever. Night Latch with Cylinder
    b. Surface Vertical Rod Exit Device: Pair; Von Duprin Commercial Grade EL9847 with E996 lever trim.
    c. Stainless steel finish; provide tactile warning on push rail. Fail Secure with key override; cylinoid, not motor operated.
3. Closers:
    a. LCN, 4040XP EDA arm.
    b. US26D, satin chromium finish.
    c. At exterior doors at NWTC, add auxiliary stop Glenn Johnson 904S; 652 finish. Use LCN EDAvST3732 arm.
5. Hinges:
    a. Provide Hager, McKinney or Ives only.
    b. Electrified: Ives 5BB1 TW8
    c. Heavy weight series; full mortise.
    d. 5 knuckle; 4 1/2" x 4 1/2" two ball bearing.
    e. 1 1/2 pair per leaf; two pair at doors taller than 7’-0”.

e. US26D, satin chromium finish.

6. Stops, thresholds, weather-stripping, door protection plates, push/pulls, flush bolts, silencers and accessories:

   a. Any major manufacturer subject to Architect's approval.

   b. Silencers: Rockwood No. 608; gray; or equal.

   c. Automatic flush bolts: Rockwood No. 1842; or equal.

   d. Manual flush bolts:

   e. Door Openers: Rixson heavy duty 1 series; concealed mount; or equal.

   f. Push/Pulls: Rockwood Series 47--70C Push/107x70C Pull, 4”x16”; .050” thick; or equal.

   g. Door protection plates to be standard duty, stainless steel; .050” thick. 12” high minimum; width to be 2” less than door width.

   h. Thresholds: ADA compliant; mill aluminum finish.

   i. Sweep Strip: Pemko 345AV by door width; or equal.

   j. Stops: Solid cast with rubber concave, concealed mounting; gray.

   k. Accessories for NREL card reader installation: HES 9600, McKinley QC-C003P and QC0C1500P; power supply by Alarmsafe; installed by VTI.

7. Fire Rated Openings:

   a. Provide UL tested and listed hardware (NFPA Standard 80).

   b. Smoke Seal to be Pemko HSS2000xS88; or approved equal.

   c. Magnetic Hold Opens to be Rixson Model; 998 or approved equal.

   d. Coordinator: Glynn-Johnson 90S/heavy-duty use or equal.

2.1 MATERIALS

A. Drawings show direction of slides, swing, or hand of each door leaf.

   1. Furnish each item of hardware for proper installation and operation of door movement as shown.

B. Do not use manufacturer's products, which have manufacturer's name or trade name displayed in a visible location (omit removable nameplates).

C. Manufacturer's identification will be permitted on rim of lock cylinders only.

D. Fasteners

   1. Provide hardware manufactured to conform to published templates, generally prepared for machine screw installation.

   2. Do not provide hardware, which has been prepared for self-tapping sheet metal screws, except as specifically indicated.

E. Furnish screws for installation with each hardware item.

   1. Provide Phillips flat-head screws except as otherwise indicated.

   2. Finish exposed (exposed under any condition) screws to match hardware finish or, if exposed in surfaces of other work, to match finish of other work as closely as possible, including "prepared to paint" in surfaces to receive painted finish.

F. Provide concealed fasteners for hardware units, which are exposed when door is closed, except to extent no standard units of type specified are available with concealed fasteners.

2.2 COMPONENTS

A. Keying

1. Contractor shall provide 5 blank keys for NREL Security use for minor construction projects.
2. Supplier will meet with Owner to coordinate keying requirements for construction keying of the project.
3. Supplier will provide construction and permanent lock cylinders and install construction lock cylinders only.
4. Owner shall be responsible for installation and keying of permanent lock cylinders.
5. Construction Keying
   a. Furnish a construction master key system with 15 keys for locks and cylinders.
   b. At the time of final acceptance of the work
      a. Void the construction key system
      b. Remove all construction lock cylinders and turn over to Owner.
   c. During construction, Contractor is responsible for control of key access to premises and project security.

B. Door Trim Units

1. Fasteners:
   a. Provide manufacturer's standard exposed fasteners for door trim units, either machine screws or self-tapping screw.

2.3 FABRICATION

A. Hardware Finishes

1. Provide matching finishes for hardware units at each door or opening, to the greatest extent possible, and except as otherwise indicated.
2. Reduce differences in color and textures as much as commercially possible where the base metal or metal forming process is different for individual units of hardware exposed at the same door or opening.
3. In general, match items to the manufacturer's standard finish for the latch and lock set for color and texture.
4. The designations used in schedules and elsewhere to indicate hardware finish, are the industry-recognized traditional U.S. finishes, except as otherwise noted.

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. Hardware Mounting Heights:

1. Mount hardware units at heights indicated in "Recommended Locations for Builders Hardware" by the Door and Hardware Institute, except as otherwise specifically indicated or required to comply with governing regulations.

B. Set units level, plumb, and true to line and location.

C. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.

D. Drill and countersink units, which are not factory-prepared for anchorage fasteners.

E. Space fasteners and anchors in accordance with industry standards.

3.2 ADJUSTING

A. Adjust and check each operating item of hardware and each door, to ensure proper operating or function of every unit.

B. Replace units, which cannot be adjusted to operate freely and smoothly as intended for the application made.

C. Final Adjustment:

1. Wherever hardware installation is made more than one month prior to acceptance or occupancy of a space or area, return to the work during the week prior to acceptance or occupancy, and make a final check and adjustment of all hardware items in such space or area.

2. Clean operating items as necessary to restore proper function and finish of hardware and doors.

3. Adjust door control devices to compensate for final operation of heating and ventilating equipment.

3.3 CLEANING

A. Clean adjacent surfaces soiled by hardware installation.

END OF SECTION

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SECTION 092216
NON-STRUCTURAL METAL FRAMING

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. Non-load-bearing steel framing systems for interior gypsum board assemblies.
2. Suspension systems for interior gypsum ceilings, soffits, and grid systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Evaluation Reports: For dimpled steel studs and runners and firestop tracks, from ICC-ES.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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.

2.2 FRAMING SYSTEMS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. 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, G40 (Z120) hot-dip galvanized unless otherwise indicated.

C. Studs and Runners: ASTM C 645. Use either steel studs and runners or dimpled steel studs and runners.

1. Steel Studs and Runners:

    a. Minimum Base-Metal Thickness: 0.018 inch.

2. Dimpled Steel Studs and Runners:

    a. Minimum Base-Metal Thickness: 0.015 inch.

D. 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. Indicate type of bridging required.
2. 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. Products: Subject to compliance with requirements, provide by one of the following:

        1) Dietrich Metal Framing.
        2) MBA Building Supplies.
        3) Steel Network Inc. (The).
        4) Superior Metal Trim.
        5) Telling Industries..

E. 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. Products: Subject to compliance with requirements, provide by one of the following:

    a. Fire Trak Corp.
    b. Grace Construction Products.
    c. Metal-Lite, Inc.

F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.

1. Minimum Base-Metal Thickness: 0.018 inch minimum.

G. Cold-Rolled Channel Bridging: Steel, 0.053-inch minimum base-metal thickness, with minimum 1/2-inch- (13-mm-) wide flanges.

1. Clip Angle: Not less than 1-1/2 by 1-1/2 inches, 0.068-inch- thick, galvanized steel.

H. Hat-Shaped, Rigid Furring Channels: ASTM C 645.

1. Minimum Base-Metal Thickness: 0.018 inch minimum.

I. Resilient Furring Channels: 1/2-inch-deep, steel sheet members designed to reduce sound transmission.

1. Configuration: Asymmetrical or hat shaped.

J. Cold-Rolled Furring Channels: 0.053-inch uncoated-steel thickness, with minimum 1/2-inch-wide flanges.

1. Furring Brackets: Adjustable, corrugated-edge type of steel sheet with minimum uncoated-steel thickness of 0.033 inch.
2. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- diameter wire, or double strand of 0.048-inch- diameter wire.

K. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches, wall attachment flange of 7/8 inch, minimum uncoated-metal thickness of 0.018 inch, and depth required to fit insulation thickness indicated.

2.3 SUSPENSION SYSTEMS

A. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- diameter wire, or double strand of 0.048-inch- diameter wire.

B. Hanger Attachments to Concrete:

1. Anchors: Fabricated from corrosion-resistant materials with holes or loops for attaching wire hangers and capable of sustaining, without failure, a load equal to 5 times that imposed by construction as determined by testing according to ASTM E 488 by an independent testing agency.

a. Type: Cast-in-place anchor, designed for attachment to concrete forms, Postinstalled, chemical anchor, or Postinstalled, expansion anchor.

2. 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, 0.16 inch in diameter.

D. Flat Hangers: Steel sheet; size as required.

E. Carrying Channels: Cold-rolled, commercial-steel sheet with a base-metal thickness of 0.053 inch and minimum 1/2-inch- wide flanges.

F. Furring Channels (Furring Members):

1. Cold-Rolled Channels: 0.053-inch uncoated-steel thickness, with minimum 1/2-inch- wide flanges, 3/4 inch deep.
2. Steel Studs and Runners: ASTM C 645.
3. Dimpled Steel Studs and Runners: ASTM C 645.
4. Hat-Shaped, Rigid Furring Channels: ASTM C 645, 7/8 inch deep.
5. Resilient Furring Channels: 1/2-inch deep members designed to reduce sound transmission.
    a. Configuration: Asymmetrical or hat shaped.

G. Grid Suspension System for Gypsum Board Ceilings: ASTM C 645, direct-hung system composed of main beams and cross-furring members that interlock.

1. Products: Subject to compliance with requirements, provide one of the following:
    a. Armstrong World Industries, Inc.; Drywall Grid Systems.
    b. Chicago Metallic Corporation; Drywall Grid System.
    c. USG Corporation; Drywall Suspension System.

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 of the Work.

B. 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.

1. Gypsum Plaster Assemblies: Also comply with requirements in ASTM C 841 that apply to framing installation.
2. Gypsum Veneer Plaster Assemblies: Also comply with requirements in ASTM C 844 that apply to framing installation.
3. 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 FRAMED ASSEMBLIES

A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

C. Install studs so flanges within framing system point in same direction.

D. 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. 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: 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 no fewer than two studs at ends of arcs, place studs 6 inches o.c.

E. Direct Furring:

1. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.

F. Z-Furring Members:
1. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.
2. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches from corner and cut insulation to fit.

G. 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.

3.5 INSTALLING SUSPENSION SYSTEMS

A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

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.
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.

END OF SECTION 092216

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SECTION 092900
GYPSUM BOARD SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

B. 1. Furnish and install all gypsum board construction indicated on the Drawings.

1.2 STANDARDS

A. GENERAL STANDARD: ANSI A97.1 except comply with requirements indicated and gypsum board manufacturer's specific instructions.

B. Analyze and provide for loads imposed on work specified in this Section by other work, such as insulation, light fixtures and similar work.

1.3 RELATED WORK

A. Section 054000 – Cold Formed Metal Framing

B. Section 072400 - Exterior Insulation and Finish System

C. Section 078413 - Firestopping

D. Section 081113 – Hollow Metal Doors and Frames

E. Section 092216 – Non-Structural Metal Framing

F. Section 093000 - Tiling

G. Section 099100 – Painting

1.4 SUBMITTALS

A. Comply with all pertinent provisions of Section 013300.

B. Submit samples of reveal accessories.

PART 2 - PRODUCTS

2.1 DRYWALL MATERIALS AND ACCESSORIES

A. STEEL GYPSUM BOARD FRAMING:

1. Screw-type ASTM C645, 25 gauge zinc coated unless heavier gauge shown, or recommended by manufacturer; complete system of members, furring strips, runners, accessories and anchors for partitions and suspended drywall ceilings.
2. Provide steel members at exterior suspended ceilings designed to resist uplift.

B. GYPSUM BOARD:

1. 5/8" thick, ASTM C36, except ASTM C442 permitted for base layers and where exposed faces indicated no to be finished; provide board with long edges tapered for joint treatment, where joint finishing is required.
2. Provide UL labeled "Type X" board where a fire resistance rating is indicated; one or two layers as shown or required.
3. Provide glass matt sheathing in all toilet rooms as shown on drawings.
4. Provide glass matt sheathing in shower enclosure.

C. GYPSUM BOARD SEALANT:

1. Non-drying mastic recommended by gypsum board manufacturer, except provide paintable elastic sealant where exposed to view.

D. GYPSUM BOARD CONTROL JOINT:

1. One piece of vinyl expanding strip, with flanges for face attachment to gypsum board. Provide where recommended by manufacturer.

E. GYPSUM BOARD TRIM ACCESSORIES:

1. ASTM C475, types recommended by drywall manufacturer.
2. Provide external corner beads with flanges for joint treatment.
3. Provide casing beads with flanges for joint treatment.
4. Provide any other trim as required and detailed; including extruded aluminum wall trim reveals.

F. JOINT TREATMENT MATERIALS:

1. ASTM C475, types recommended by drywall manufacturer.

PART 3 - EXECUTION

3.1 GYPSUM BOARD INSTALLATION

A. Comply with the recommendations of Gypsum Association, GA-216, specifications for the application and finishing of gypsum board.

B. Isolate steel stud framing from overhead structural work, to prevent bearing stresses; comply with gypsum board manufacturer's instructions.

C. Terminate gypsum board partitions at bottom structure, except as otherwise indicated.

D. Space gypsum board framing (studs, z-furring strips) as indicated.

1. Provide extra jamb members, corner members and edge members, and provide rough framing of openings as recommended by manufacturer.
2. Anchor to door frames and supporting structure as recommended. Spacing: 24" o.c., except as otherwise shown or required.
3. Provide internal bracing as required.

E. Provide 5/8" thick gypsum board throughout; Type “X” where rated walls are indicated, andwater resistant in wet areas.

F. Form control joints as shown, with joint trim and treatment.

G. For vertical partition gypsum board installation, offset joints on opposite sides of wall.

H. Install gypsum board in lengths and directions which will minimize number of end joints.

I. Screw (do not nail) gypsum board to supports as recommended by manufacture

J. Provide gypsum board sealant at interruptions and openings through work, concealed behind edge of board wherever possible. Caulk between gypsum board and slab at all partitions receiving acoustical insulation.

K. For direct adherence of gypsum board to substrate where shown, comply with manufacturer's recommendation for method of application and temporary support.

L. Trim gypsum board at external corners with corner beads.

M. Provide casing bead at exposed edges of gypsum board and wherever gypsum board abuts flush with other wall or ceiling finish.

N. Provide flush joint treatment screw-head treatment for exposed gypsum board work. Apply tape and compound in not less than 3 applications, sanding smooth after first two applications. Finish gypsum board with a very light texture as selected by NREL.

O. Provide continuity of fire rated gypsum board membrane in ceilings at recessed items by providing fire-rated bonnet at ceilings and boxing out at walls.

END OF SECTION

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SECTION 095113
ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install suspended acoustical ceiling grid and tiles in all areas indicated on Drawings.

1.2 STANDARDS

A. Ceiling Tiles: FS SS S-118B Class A, 0-25 flame spread (ASTM E84) NRC Range .50-.70, STC Range 30-39.

B. Suspension Systems: ASTM C 635 intermediate, standard specifications for metal suspension systems for acoustical tile and lay-in panel ceilings; for materials, ASTM C 636 recommended practice for installation of metal suspension system for acoustical tile and lay-in panels for installation.

C. Terminology and Performances: Current bulletin by AIMA "Performance Data, Architectural Acoustical Materials".

D. Fire Hazard: UL "Classified Buildings Materials Index", ASTM E 84, 0-25.

E. Fire Resistance: None

1.3 SUBMITTALS

A. Comply with all pertinent provisions of Section 01330. Provide product data for all products to be utilized.

B. Submit three samples 12" square, of each exposed acoustical unit; and three samples, 24" long, of each exposed suspension member and molding.

C. Submit manufacturer's catalog data, performance information, and published certification data indicating compliance with the specifications.

PART 2 - PRODUCTS

2.1 PANELS

A. PANELS (Standard): 24" x 24" x 5/8" non-combustible, non-directional fissured units by any major manufacturer of acoustical ceilings. Washable white finish. Provide manufacturer's standard warranty against sagging and/or warping.

2.2 SUSPENSION SYSTEM

A. As required to support acoustical units, fixtures and other components as indicated, and including anchorages, hangers, runners, cross runners, splines, clips, moldings, fasteners and other members, devices and accessories. Contractor responsible for adequacy of suspension system, and determining method of attachment of system to supporting structure.

B. Hanger Wire: Not less than 12 gauge (0.106") galvanized steel.

C. Exposure: Fully-exposed (lay-in) suspension system. All areas indicated to receive lay-in tile shall be standard, square edge, lay-in suspension system; coordinate suspension height to provide indicated ceiling height to face of tile.

D. Exposed Finish: Low-Gloss vinyl latex, color: white

PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout: See Drawings

B. Tolerance: 1/8" in 12'-0" level tolerance.

C. Pattern Direction: One-way alignment of joints.

D. Suspension System: Secure to building structure, with hangers spaced maximum of 4'-0" along supported members. Cope exposed flanges of intersecting suspension members for flush intersections.

E. Perimeter treatment: Regularize panel edges at perimeter moldings as required.

F. Grid pattern to be centered in room with minimum panel widths of 1'-0" at walls, or as indicated on the Drawings.

G. Penetrations such as lights, sprinkler heads, detectors, etc., are to be centered in full tiles.

END OF SECTION

SECTION 096513
RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: –

1. Rubber Base.
2. Rubber Stair Accessories
3. Resilient Molding Accessories.

1.2 REFERENCES

A. Federal Specifications (Fed. Spec.)

1. SS-W-40A - Wall Base: Rubber.

1.3 SUBMITTALS

A. Warranty

1. Submit a statement of compliance for materials.

B. Samples

1. Submit 12-inch-long Samples of each material representing complete range of color and pattern.

C. Maintenance Instructions

1. Furnish maintenance instructions for care and cleaning of base and accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in manufacturer's original unopened containers with manufacturer's name, brand name, grade, color, pattern and other pertinent information clearly marked thereon.

B. Store materials in their original containers at minimum temperature of 70 degrees F for at least 24 hours before installation.

1.5 PROJECT CONDITIONS

A. Maintain spaces to receive the Work at minimum temperature of 70 degrees F at floor level for at least 48 hours prior to, during, and for 48 hours after completion of the Work.

PART 2 - PRODUCTS

2.1 RESILIENT BASE

A. Rubber as manufactured by Roppe or Burke Mercer Flooring Products. Manufacturer and color per building standard.

B. Fed. Spec. SS-W-40A, 4 inches high and of topset cove style, unless otherwise indicated or specified, with premolded smooth top and cove, provided in as long lengths as practicable to suit conditions of installation.

C. Color: as indicated on the Drawings.

D. Adhesive for resilient base: waterproof adhesive recommended by the manufacturer of the base.

2.2 ACCESSORY MATERIALS

A. Transition Accessories

1. Rubber as manufactured by the approved manufacturer of the rubber base. Color to match rubber base.
2. Color: as indicated on the Drawings.
3. Adhesive: waterproof adhesive recommended by the manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that substrates and conditions are satisfactory. Do not allow resilient base and accessories work to proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrate surfaces as follows:

1. Use leveling and patching compounds as recommended by the manufacturer for filling small cracks, holes and depressions in substrates.
2. Remove coatings, including curing compounds, 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.

B. Broom and or vacuum clean substrates to be covered, and inspect substrates for moisture, alkaline salts, carbonation or dust.

3.3 FLOORING TRANSITION ACCESSORIES

A. Resilient Edge Strips (Reducers) and Thresholds

1. Provide resilient edge strips where floor covering terminates exposing the edge of the covering. Center under door where floor covering terminates at a door opening, or as indicated.

B. Installation

1. Fit resilient materials to finish flush with abutting flooring and against flooring and other abutting materials, with no joint greater than 1/64 inch. Scribe to configuration of door frames and other abutting construction.
2. Bond resilient materials securely to substrate in full bed of adhesive.

3.1 RESILIENT BASE

A. Installation

1. Cut base material into accurate lengths as required for minimum number of joints. Match edges at all seams or double-cut adjoining lengths.
2. Bond base to substrates in full bed of adhesive. Install with tight butt joints with no joint widths greater than 1/64 inch. Press down so that bottom cove edge follows floor profile. Top and bottom edges shall have firm contact with floor and wall surfaces.
3. Form internal corners by mitering. Form external corners by coping and bending material sufficient length around corner for anchorage.
4. Scribe base accurately to abutting materials.
5. Provide base against front and exposed sides of all casework and on wall at knee spaces.
6. Provide base on wall behind casework where resilient flooring extends under casework.

7. Provide base on columns in areas scheduled to receive resilient flooring.

3.2 CLEANING

A. Upon completion of Work in a space, clean surfaces free of adhesive, dirt and other foreign materials in accordance with the instructions of the tile manufacturer.

3.3 PROTECTION

A. Protect the Work against mars, marks, indentations and other damage from construction operations and placement of equipment and fixtures during the remainder of the construction period. Use protection methods recommended in writing by resilient product manufacturer.

END OF SECTION

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SECTION ~~093000~~096519
RESILIENT TILE FLOORING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. All labor, materials, equipment and services necessary to furnish and install all resilient flooring and related items as indicated or specified.

B. Related Sections

1.2 SUBMITTALS

A. Submit samples of the following for approval:

1. Resilient tile
2. Base
3. Nosings

B. All submittals shall be prepared in accordance with Section 013300.

1.3 DELIVERY, STORAGE AND PROTECTION

A. Store all materials off the ground under watertight cover and away from sweating walls and other damp surfaces until ready for use.

B. All rooms, subfloors, tiles and adhesives shall be maintained at a minimum temperature of 70 degrees F for at least 48 hours before commencing work.

C. Temperature shall be maintained during installation and for at least 48 hours after completion.

D. Remove damaged or deteriorated material from the premises.

E. Protect finished work installed by other trades prior to work under this Section. Any work damaged by workers of this trade shall be replaced without cost to the Owner.

1.4 MAINTENANCE

A. Sweep daily with a soft broom, treated cloths, or treated mops which will remove dirt and dust build-up.

B. Wash resilient floors every two weeks in light traffic areas and more often in areas that receive heavy spillage.

1. This light duty cleaning does not require the removal of the polish finish.
2. Alkaline cleaners should not be used because the residue may dull the glossy finish.

C. Floor protectors are required to retain the beauty of resilient flooring.

1. Flat composite cups shall be used under furniture legs to allow for a more even distribution of the weight.
2. Furniture that is frequently moved shall be equipped with casters 2 inches in diameter with soft rubber treads at least 3/4 inch wide.
3. Glides shall have a smooth, flat base with rounded edges and a flexible shank.
4. The glides should be 1-1/4 to 2-1/2 inches in diameter.
5. Protectors shall be cleaned each time the floor is washed to prevent scratch buildup.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Armstrong Excelon

B. Azrock

C. Tarkett

2.2 MATERIALS

A. Vinyl Composition Tile

1. 12"x12", 1/8" thick, or Vinyl Sheeting
2. Colors, as selected, from standard patterns and colors

B. Rubber Base

1. Molded rubber cove base (top set)
2. 4" high x 1/8" thick
3. Colors, as selected, from full color range of manufacturer.

C. Vinyl Base

1. Vinyl cove base (top set)
2. 4" high x 1/8" thick
3. Colors, as selected, from full color range of manufacturer.

D. Flooring Adhesives:

1. As per flooring manufacturer's recommendations.

E. Edging Strips

1. 1/8" thick
2. Vinyl or rubber
3. Tapered or bullnose edge
4. Color to match tile or as selected from manufacturer's colors.

F. Base Adhesives:

G. Underlayment

H. Molded Rubber Stair Nosings

1. 1/4" thick
2. Square nose
3. Color as selected
4. Double lock type

I. Nosing Adhesive:

PART 3 - EXECUTION

3.1 PREPARATION

A. Inspect all surfaces to receive tile base and treads and report all defects that will affect the installation.

B. Fill low areas with underlayment.

C. Fill all joints, cracks and chips in sub-floor with a crack filler or underlayment as required to provide a true, even surface to receive cove base.

D. Concrete surfaces to receive tile or base shall be dry, free of paint and oil, and swept clean before work commences.

E. Contractor shall be held responsible for any defects in the sub-floor, which appear in the flooring surface after completion.

3.2 INSTALLATION

A. After preparation of surfaces, apply adhesive in a thin film and spread evenly with a serrated trowel with notches 1/16" x 1/16", 1/8" apart.

B. Direction of graining shall be as directed.

1. Lay out work so that, as far as practicable, no piece of tile shall be less than 5" wide, particularly at doors.

C. All joints shall be tight, in true alignment, and as inconspicuous as possible.

1. Where two colors meet at door openings or where tile terminates at doors to rooms having exposed concrete floors, provide a 1"-wide feature strip directly under the door.
2. NREL shall have the option of selecting different colors in different areas or rooms.

D. Cut and fit tile sufficiently close to walls, columns, etc., so that joint will be covered by the base, where installed.

E. At other fixed surfaces, including thresholds, pipes, removable covers, floor outlets and permanent built-in cabinets and equipment, scribe and accurately fit tile as required.

F. Provide tile inserts at removable floor outlet covers. Remove excess adhesive from all surfaces immediately.

G. Seal joints at pipes with waterproof cement.

H. Provide underlayment as required to bring resilient tile surface to the same level as abutting ceramic tile, or other flooring.

I. Install rubber stair nosings per manufacturer's instructions.

J. Base

1. After preparation of wall surfaces, apply adhesive to back of base, leaving top 1/4" free of adhesive.
2. Press base firmly against the walls sliding horizontally into place, making sure toe is tight to the floor and against the wall.
3. Roll the entire surface of the base with a hand roller, and press the top of the base against the wall with a straightedge.
4. Remove excess adhesive immediately.
5. Install preformed corners at all outside corners.

6. Cope at internal corners.

7. Where base terminates at projections install end caps.

3.3 CLEANING

A. Clean floors by a method recommended by the manufacturer of the flooring.

B. Wax the tile after the adhesive has had an opportunity to reach its final, firm set.

1. This period of time shall be at least two days after laying the flooring in the summertime and at least five days after laying the flooring in the heated building of wintertime.

C. Paste or liquid-solvent waxes, which contain solvents such as naphtha or turpentine, should not be used on resilient flooring.

D. Resilient flooring shall never be treated with lacquers, varnishes, or similar finishes due to discoloring and be difficulty in removing.

E. After the cleaning and waxing operation, polish the floor with an electric polisher to a smooth, even and highly reflective finish.

F. Protect the flooring with heavy paper until acceptance of the work.

END OF SECTION

SECTION 096813
TILE CARPET

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. This Section includes carpet tile.

1.3 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. Doorways, enclosing walls and locations where cutouts are required in carpet tiles.
2. Existing flooring materials to remain.
3. Carpet tile type, color, and dye lot.
4. Pattern of installation.
5. Pattern type, location, and direction.
6. Pile direction.
7. Type, color, and location of edge, transition, and other accessory strips.
8. 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” long samples.

D. 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.

E. Warranty: Special warranty specified in this Section.

1.4 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. Mockups: Before installing carpet tile, build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Approved mockups may become part of the completed Work if undamaged at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI 104, Section 5, "Storage and Handling."

1.6 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 existing concrete slabs until slabs have been properly prepared and accepted.

1.7 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.

1.8 EXTRA MATERIALS

A. Furnish extra materials before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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:

B. Products: Subject to compliance with requirements, provide the following or approved equal:

1. Manufacturer:
    a. Color: TBD
    b. Pattern:
    c. Source:

C. Fiber Type:

D. Pile Characteristic:

E. Density:

F. Electrostatic Propensity - AATCC Test Method 134-1996, max. average voltage:

G. Pile Thickness:

H. Stitches:

I. Gage:

J. Surface Pile Weight:

K. Total Weight:

L. Primary Backing/Backcoating:

M. Secondary Backing:

N. Size: 24” x 24”

O. Applied Soil-Resistance Treatment:

P. Antimicrobial Treatment:

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.

1. VOC Limits: Provide adhesives that comply with the following limits for VOC content when tested according to ASTM D 5116:

   a. Total VOCs: 10.00 mg/sq. m x h.

   b. Formaldehyde: 0.05 mg/sq. m x h.

   c. 2-Ethyl-1-Hexanol: 3.00 mg/sq. m x h.

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. Subfloors are free of cracks, ridges, depressions, scale, and foreign deposits.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

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. Maintain dye lot integrity. Do not mix dye lots in same area.

C. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds. Bind or seal cut edges as recommended by carpet tile manufacturer.

D. Extend carpet tile into door reveals, 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.

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

SECTION 099100
PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. All labor, materials, equipment, and services necessary to complete all painting and finishing required for surfaces as indicated or specified.

1.2 RELATED SECTIONS

A. Section 092900 "Gypsum Board" for finish level.

1.3 DEFINITIONS

A. Gloss Level 1: Not more than 5 units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523. Flat Sheen; dry location ceilings and soffits.

B. Gloss Level 2: Not more than 10 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523. Velvet Sheen; ceilings and soffits, as directed by NREL

C. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523. Eggshell Sheen: dry location walls.

D. Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D 523. Satin Sheen: dry location walls, as directed by NREL.

E. Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523. Semi-gloss Sheen: wet location walls, ceilings and soffits.

F. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523. Gloss Sheen: sterile locations as directed by NREL; provide Level 5 drywall finish.

G. Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D 523. High-Gloss Sheen: sterile locations as directed by NREL; provide Level 5 drywall finish.

H. Volatile Organic Compounds (VOC): Substances that cause odor in liquid finishes.
For interior paints and coatings applied at Project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 150 g/L.
3. Dry-Fog Coatings: 400 g/L.
4. Primers, Sealers, and Undercoaters: 200 g/L.
5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
6. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
7. Pretreatment Wash Primers: 420 g/L.
8. Floor Coatings: 100 g/L.
9. Shellacs, Clear: 730 g/L.

1.4 SYSTEM DESCRIPTION

A. Color selections are based on Sherwin Williams colors. No alternates or substitutions will be allowed.

1.5 SUBMITTALS

A. Provide samples of paint colors as specified by NREL.

B. Refer to the "Finish Schedule" on the drawing for designated finishes of areas.

1. Responsibility for recommending, scheduling and using the proper paint for the job conditions rests with the manufacturer and painting subcontractor.

1.6 QUALITY ASSURANCE

A. All material shall comply with the following standards:

1. All liquid surface finishes to contain no VOCs.
2. All liquid surface finishes to be without out-gassing and odor.

1.7 DELIVERY, STORAGE AND PROTECTION

A. Deliver all paint to site in manufacturer's labeled and sealed containers.

1. Labels shall give manufacturer's name, brand, type, batch number, color of paint and instructions for reducing.
2. Thin only in accordance with printed directions of manufacturer.

B. Store all material used on the job in a single designated space.

1. Storage space shall be kept clean.
2. Any damage to it or to its surroundings shall be repaired by Contractor.
3. Remove any oily rags, waste, etc. from the building every night and take every precaution to avoid any danger of fire.
4. In no case shall amount of materials stored exceed that permitted by local ordinances, state laws, or fire underwriter regulations.

1.8 PROJECT/SITE CONDITIONS

A. Do not apply varnish or paint when temperature is below 50 degrees, or above 95 degrees Fahrenheit.

B. Avoid painting surfaces when exposed to hot sunlight.

C. Before painting, remove hardware, accessories, plates, lighting fixtures, and similar items or provide ample protection of such items.

D. On completion of each space, replace above items.

E. Use only skilled tradesmen, as required by NREL, for removing and connecting above items.

F. Protect adjacent surfaces as required or directed.

G. Any damage done shall be repaired by the Painting Contractor at his expense.

H. A sufficient supply of clean drop cloths and other protective covering shall be properly distributed and maintained.

I. Finishing of the following items and materials will not be required UNLESS SPECIFIED AS SUCH, and shall be protected:

1. Stainless steel, brass, bronze, copper, chromium, anodized aluminum; specially finished articles such as porcelain enamel, plastic-coated fabrics, and baked enamel.
2. Finished products such as ceramic tile, windows, glass, brick, resilient flooring, acoustical tiles, board and metal tees; other architectural features, such as "finish" hardware, finished in aluminum, bronze or plated ferrous metal, prefinished panels, or other items that are installed prefinished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Wolf Gordon Scuff Master Environmental; two coats, rolled; color G5257429 at **RSF I only** (B and C Wings) hollow metal frames. Coordinate primer with approved surface of hollow metal frame.

B. Sherwin Williams: For interior hollow metal door and window frames, provide DTM acrylic DTM zero VOC interior latex; semi-gloss.

C. Sherwin Williams: For interior gypsum surfaces, use ProMar 200 zero VOC interior latex with B28W02600 primer.

2.2 MATERIALS

A. All paint materials shall be factory fresh.

B. Basic painting materials such as linseed oil, shellac, turpentine, thinners, driers, etc. shall be of highest quality, made by reputable manufacturers as specified, have identifying labels on containers and shall be approved by NREL.

C. 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 coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

PART 3 EXECUTION

3.1 PREPARATION

A. Inspection of Surfaces:

1. Do not begin painting on any surface until it has been inspected and is in proper condition to receive the paint as specified.
2. The General Contractor shall be notified in writing of any unsuitable surfaces for a proper paint finish.
3. Apply no material until the unsuitable surfaces have been made satisfactory.
4. After acceptance of surface, by application of first coat of paint, painting contractor is responsible for rectifying any unsatisfactory finish.

B. If, after treatment, the completed finish (or any portion thereof) blisters, checks, peels, or otherwise shows indication of dampness or other irregular condition of surface, the painting contractor shall, at his own expense, remove the applied treatment and refinish the part affected to the satisfaction of the NREL.

C. The painting contractor shall determine dryness of all moisture-holding materials by use of a reliable electronic moisture meter.

D. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

3.2 INSTALLATION APPLICATION

E. Stain or paint only when surfaces are clean, dry, smooth and adequately protected from dampness.

F. Each coat of paint shall be well brushed, rolled or sprayed on, worked out evenly and allowed to dry at least 24 hours before the subsequent coat is applied.

G. Paint roller cover shall be 1/2” sheepskin roller. Surface to be primed, painted and backrolled.

H. Finished work shall be uniform, of approved color, smooth and free from runs, sags, clogging or excessive flooding.

I. Make edges of paint adjoining other materials or colors sharp and clean, without overlapping.

J. Where high gloss enamel is used, lightly sand undercoats to obtain a smooth finish coat.

K. Each coat of material applied must be inspected and approved by NREL before the application of the succeeding specified coat; otherwise no credit for the concealed coat will be given, and the Contractor shall assume the responsibility to recoat the work in question.

L. Painting Contractor shall notify NREL when each coat is completed.

M. At completion, touch up and restore finish where damaged and leave finish surfaces in good condition.

N. Wood

1. Sandpaper to smooth and even surface and then dust off.
2. After priming or stain coat has been applied, thoroughly fill all nail holes and other surface imperfections with putty tinted with primer or stain to match wood color.
3. Sand all woodwork between coats to a smooth surface.
4. Cover knots and sap streaks with a thin coat of shellac.

O. Steel and Iron

1. Remove grease, rust and rust scale and touch up any chipped or abraded places on items that have been shop coated.

2. Where steel or iron has a heavy coating of scale, remove by descaling, or wire brushing, as necessary, to produce a satisfactory surface for painting.
3. When area will be exposed to view, sandpaper the entire treated area smooth, feather the edge of surrounding undamaged prime coat and spot prime in a manner to eliminate evidence of repair.

P. Galvanized Metal

1. Thoroughly clean by wiping surfaces with surface conditioner and prime with galvanized iron primer as recommended by paint manufacturer.

Q. Concrete and Concrete Masonry

1. Prepare surfaces to be painted by removing all dirt, dust, oil and grease stains and efflorescence.
   a. The method of surface preparation shall be left to the discretion of the painter, provided the results are satisfactory to NREL.
2. Before first paint coat is applied, spot prime any nails and other exposed metal occurring in the surfaces with an oil-base masonry primer as recommended by paint manufacturer.

R. Plaster Surfaces

1. Fill cracks, holes or imperfections in plaster with patching plaster and smooth off to match adjoining surfaces.
2. Before painting any plaster, surfaces shall be first tested for dryness with a moisture-testing device.
   a. Apply no paint or sealer on plaster when the moisture content exceeds 12% as determined by the testing device.
   b. Test sufficient areas in each space and as often as necessary to determine the proper moisture content for painting.
      1) If the moisture content is between 8% and 12%, prime with alkali-resistant primer.
      2) If 8% or less, prime with specified primer.
3. Remove the dry salt deposits from all plaster surfaces by brushing with a stiff brush before painting.

4.1 Painting Schedule

	Color Name	Number	Location
Piping Paint	(excluding ESIF)		
PP1	Lime Tart	BM 2033-40	Domestic Water
PP2	Miami Green	BM 2042-40	Condenser / Process Water
PP3	Yellow Rain Coast	BM 2020-40	DOM Hot Water Loop
PP4	Bud Green	BM 2033-50	D.I. Water
PP5	Citrus Orange	BM 2016-20	Natural Gas / Fuel Oil
PP6	Irish Clover	BM 2038-20	Oxygen
PP7	Red	BM 2000-10	Fire Lines
PP8	Black	BM 2132-10	Drain & Vents
PP9	Aruba Blue	BM 2048-30	HWS / HWR
PP10	Ocean Breeze	BM 2058-60	Lab Air:
PP11	Ol' Blue Eyes	BM 2064-30	HVAC Units & Supply Duct
PP12	Brickstone Red	BM 2005-30	Exhaust Duct
PP13	Georgian Revival Blue	SW7609	Comp Air Over 90lbs
PP14	Valentine's Day	BM 2077-60	Vacuum
PP15	Plum Royale	BM 2070-20	Nitrogen
PP16	Spectra Blue	BM 2049-50	Lab Waste
PP17	Marina Bay	BM 2036-50	Chilled Water
PP18	Eclipse	BM 2132-40	ERWR and ERWS
Office and Laboratory: (minus SERF and STF)			
P1	Westhighland White	SW7566	General Wall color, or ceiling
P2	Independent Gold	SW6401	Accent
P3	Sassy Green	SW6416	Accent
P4	Rain	SW6220	Accent; FTLB Doors
P5	Delft	SW9134	Accent
P6	Rainwashed	SW6211	Accent
P7	Wall Street	SW7665	Door Frames
P8	Sunflower	SW6678	Accent
P9	Flower Pot	SW6334	Accent
P10	Ice Mist	BM OC-67	General Wall color, or ceiling
P11	Skyline Steel	SW1015	Accent
P12	Elephant Ear	SW9168	RSF II, SEB, Café, Hollow Metal Frames
P13	Sensible Hue	SW6198	Accent
P14	Urbane Bronze	SW7048	Door Frames
P15	Manitou Blue	SW6501	Café Counter at Common Grounds
P16	Freesia	BM 1432	Café Divider Wall
P17	Gray Mountain	BM 1462	ESIF Exposed Interior Steel Cross Bracing
P18	Pewter	BM 2121-30	ESIF Visualization Rooms
P19	Mojave Desert	BM 1115 Classic	RFHP Silo only

P20	Lakeshore	SW6494	RSF Accent
P21	Spicy Hue	SW6342	RSF Accent
P22			Café Ceiling
P23	Gossamer Veil	SW 9165	NWTC Accent
P24	South Port	Behr PX0724	NWTC Accent
	Head of Lettuce	Behr PX0409	

SERF-Solar Energy Research Facility

P1	Westhighland White	SW7566	Walls and HM doors
P2	Friendly Yellow	SW6680	Service Corridors, Lobby
P3	Whitetail	SW7103	Metal Deck; exposed steel structure
P4	Rain	SW9134	Accent Wall
P5	Delft	SW6220	Accent Wall
PP1	Rally Green	SW6934	Domestic Water
PP2	Vegan	SW6738	Process Chilled Water
PP3	Active Green	SW6986	Chilled Water Supply/Return
PP4	Ruby Shade	SW6572	Nitrogen
PP5	Nifty Turquoise	SW6941	Domestic Hot Water
PP6	Whitetail	SW7103	Ducts

Notes:
1. Wall and door frame match color.
2. Waste piping: not painted; Fuseal, light blue.

STF-Science and Technology Facility

P1/P4	Pure White	SW7055	Walls and HM doors
P2	Full Moon	SW6679	Accent Wall
P3/P6	Dorian Gray	SW7016	Service Corridor
P5/P7	San Antonio Sage	SW7731	Accent Wall

Painting Notes

1. Paint hollow metal doors and frames to adjacent match wall in SERF and S&TF. Service corridor surfaces and labs, along with hollow metal frames, are semi-gloss. Public corridors are egg shell.

Flatirons Campus: Exterior

Birdhouse: Worldly Gray SW7043
Exterior Trim: Doors, Canopy: Snowbound SW7004
Trailers:
Field.Trim: Utterly Beige SW6080
Doors: Diverse Beige SW6079
Site Entrance Post: Granite Peak SW6250
251 Sun Shade Canopy: SW 4010 Pumice Stone; SW Protective & Marine Coatings

END OF SECTION

SECTION 210500
COMMON WORK RESULTS FOR FIRE SUPPRESSION

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 SUMMARY

A. This Section includes the basic materials and methods for components associated with the following Fire Suppression Systems:

1. Wet-pipe fire-suppression system, including piping, valves, specialties, automatic sprinklers, and standpipe.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe 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 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. CPVC: Chlorinated polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.
2. B16.3 - Malleable Iron Threaded Fittings.
3. B16.4 - Gray Iron Threaded Fittings.
4. B16.5 - Pipe Flanges and Flanged Fittings.
5. B16.9 - Factory-Made Wrought Steel Buttwelding Fittings.
6. B16.11 - Forged Steel Fittings, Socket-Welding and Threaded.
7. B36.10M - Welded and Seamless Wrought Steel Pipe.

B. American Society for Testing and Materials (ASTM):

1. A47 - Specification for Ferritic Malleable Iron Castings.
2. A53 - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
3. A135 - Specification for Electric-Resistance-Welded Steel Pipe.
4. A536 - Specification for Ductile Iron Castings.
5. A795 - Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.
6. A865 - Specification for Threaded Couplings, Steel, Black or Zinc-Coated (Galvanized) Welded or Seamless, for Use in Steel Pipe Joints.

C. American National Standards Institute (ANSI):

1. A13.1 – Scheme for Identification of Piping Systems.

D. American Water Works Association (AWWA):

1. C606 - Grooved and Shouldered Joints.

E. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.(MSS):

1. SP-80 – Bronze Gate, Globe, Angle and Check Valves.

F. National Fire Protection Association (NFPA):

1. 13 - Installation of Sprinkler Systems
2. 14 - Installation of Standpipe, Private Hydrant, and Hose Systems
3. 24 - Installation of Private Fire Service Mains
4. 70 - National Electrical Code.
5. 291 – Fire Flow Testing and Marking of Hydrants.
6. 1963 – Fire Hose Connections.

G. Underwriters Laboratories Inc. (UL):

1. Fire Protection Equipment Directory.
2. 45 – Portable Electric Tools.
3. 213 – Rubber-Gasketed Fittings for Fire Protection Service.
4. 262 - Gate Valves for Fire Protection Service.
5. 312 – Check Valves for Fire Protection Service.
6. 405 – Fire Department Connections.
7. 789 – Indicator Posts for Fire Protection Service.
8. 1091 – Butterfly Valves for Fire Protection Service
9. 1821 – Thermo-Plastic Sprinkler Pipe and Fittings for Fire Protection Service.

1.5 SUBMITTALS

A. Shop Drawings, Product Data and Samples: Submit Shop Drawings, Product Data and Samples for the materials, equipment and systems (products) so specified elsewhere in Division 21sections of the Specifications.

B. See Division 1 sections of the Specifications for submittal requirements and for product options and substitutions.

C. Shop Drawings and Product Data:

1. Before any Work is commenced, the following: Shop Drawings, sprinkler system hydraulic calculations including standpipe pressure and flow, material and equipment lists and full descriptive data for each system for approval to:

   a. Local Fire Marshal

   b. Owner

   c. Architect

2. Obtain approval of Shop Drawings, hydraulic calculations, and Product Data from the Fire Marshal prior to submission to the Owner and the Architect.

3. Partial submittals are not acceptable.

4. Include in Shop Drawings reflected ceiling plans showing sprinkler head locations.

5. Submit sprinkler drawings which are legible and show:

   a. Exact piping arrangement and show all pipe lengths, valves, fittings and sizes.

   b. Section views and sufficient notes to provide full descriptive data for review, except for flow-requirements which shall be shown on calculation sheets.

   c. Standpipe system type and class.

6. Coordination with all drawings is required for bidding and installation.

7. Submit manufacturers data sheets on all system components including the following:

   ~~a. Underground pipe and fittings~~

   ~~b. Underground valves~~

   ~~c.~~a. Aboveground pipe and fittings

   ~~d.~~b. Aboveground valves

   ~~e. Reduced pressure backflow preventer~~

   ~~f.~~c. Pipe hangers and supports

   ~~g.~~d. Sleeves

   ~~h.~~e. Escutcheons

   ~~i.~~f. Identification signs

   ~~j. Antifreeze~~

   ~~k. Pressure gages~~

   ~~l. Supervisory tamper switches~~

   ~~m. Water flow switches~~

   ~~n. Sprinkler heads and cabinets~~

o. Alarm valve

p. Fire department connection

q. Wall hydrant

r. Motor Submittal Data: The following data shall be submitted for all motors:

1) Full load current and service factor running current at operating voltage.
2) Locked rotor current, starting power factor and power factor at full load.
3) Efficiency at full load.
4) Data to substantiate Class F insulation with Class B rise at 100% load.
5) Full load speeds (fpm).
6) Enclosure type (ODP, TEFC, explosion proof, TENV, WPI, etc.).
a) *Note: All tests (except locked rotor current) shall be made at full voltage and rated frequency.*

s. Motor Controllers:

1) Torque, speed, and horsepower requirements of the load.
2) Rating and characteristics of supply circuit and required control sequence.
3) Ambient and environmental conditions of installation location.

t. Capacitor size (KVAR) for maximum power factor correction at 95% lagging.

D. Fire-Hydrant Flow Test Report: As specified in "Preparation" Article in Part 3 of this section.

E. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction. Include hydraulic calculations.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

G. Maintenance Data: For each type of standpipe and sprinkler specialty to include in maintenance manuals specified in Division 1sections of the Specifications.

H. Record Drawings: Upon completion of the Work, provide a complete set of reproducible record drawings of each fire protection system on mylar film with title block similar to full size Project Drawings.

I. Operation and Maintenance Manuals:

1. Submit operation and maintenance manuals for each mechanical system, except as otherwise specified herein, and for each piece of equipment.

2. Submit 1 draft copy of each manual at least 15 days before requesting inspection for Substantial completion. Include a complete operation and maintenance directory. Architect will return the copy indicating whether scope and general content of manuals are acceptable.

3. Include the names, addresses, and telephone numbers of each subcontractor installing equipment and systems and of local representatives for each item of equipment and each system. Provide a table of contents and assemble the manual to conform to the table of contents with the tab sheets placed before instructions covering the subject. Instruction sheets shall be legible and easy to read, with large sheets of drawings folded in.

4. Include the following in the manual:
    a. A system description and layout showing piping, valves, and controls
    b. Wiring and control diagrams with data to explain detailed operation and control of each component
    c. A control sequence describing start-up, operation and shutdown
    d. A detailed description of the function of each principal component of the system
    e. The procedure for starting
    f. The procedure for operation
    g. Shutdown instructions
    h. Installation instructions
    i. Maintenance and overhaul instructions
    j. Lubrication schedule including type, grade, temperature range, and frequency
    k. Safety precautions, diagrams, and illustrations
    l. Test procedures
    m. Performance data
    n. Parts lists
5. In the parts lists for equipment, indicate the sources of supply, recommended spare parts, and the service organization which is reasonably convenient to the building site.
6. Provide the manual complete in all respects for all equipment, controls, accessories, and associated appurtenances provided.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has designed and installed fire-suppression piping similar to that indicated for this Project and obtained design approval and inspection approval from authorities having jurisdiction.

B. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer. Base calculations on results of fire-hydrant flow test.

C. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of fire-suppression piping that are similar to those indicated for this Project in material, design, and extent.

D. Manufacturer Qualifications: Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in UL's "Fire Protection Equipment Directory" and FM's "Fire Protection Approval Guide" and that comply with other requirements indicated.

E. Standpipe and Sprinkler Components: Listing/approval stamp, label, or other marking by a testing agency acceptable to authorities having jurisdiction.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

G. NFPA Standards: Equipment, specialties, accessories, installation, and testing complying with NFPA 13, 13R, 14, and 230.

1.7 WARRANTY

A. General:

1. Submit Special Warranties for the products so specified elsewhere in Divisions 21 sections of the Specifications.

2. Submit Statements of Compliance for the products so specified elsewhere in Divisions 2, and 21 sections of the Specifications.

B. Service During Contract Correction Period:

1. In the event of the failure of any system or its component equipment items or the improper functioning thereof, within the period provided in The Conditions of the Contract for correction of the Work, or within such longer period of time as may be prescribed by law or by the terms of any applicable special warranty required elsewhere in Division 21 sections of the Specifications, have available and "on call" within eight hours or less, competent service personnel for the restoration of systems and equipment for complete operation.

2. Should the nature of the failure be such as to present an emergency, in the opinion of the Owner, make such personnel promptly available, regardless of the hour of the day or the day of the week.

3. Should the failure be such as to fall under this warranty, pay the cost of the services; otherwise the Owner will pay for such service at the prevailing rate.

4. Should the Contractor fail to make such service personnel available "on call" within eight hours or less, the Owner may employ such personnel as are available to the Owner, at the expense of the Contractor.

PART 2 - PRODUCTS

2.1 MATERIALS

~~A. Underground Piping, Fittings and Valves: See Division 2 sections of the Specifications.~~

~~B.~~A. Aboveground Piping:

1. Standard-Weight Steel Pipe: ASTM A53, ASTM A135, or ASTM A795; Schedule 40 in NPS 6 and smaller, and Schedule 30 in NPS 8 and larger.

2. Schedule 30 Steel Pipe: ASTM A135 or ASTM A795, with wall thickness less than Schedule 40 and equal to or greater than Schedule 30 or ASTM A795 and ASME B36.10M, Schedule 30 wrought-steel pipe.

3. Thinwall, Threadable Steel Pipe: ASTM A135 or ASTM A795, with wall thickness less than Schedule 40 and greater than Schedule 10.

4. Schedule 10 Steel Pipe: ASTM A135 or ASTM A795, Schedule 10 in NPS 5 and smaller and NFPA 13 specified wall thickness in NPS 6 to NPS 10.

5. Thinwall Steel Pipe: ASTM A135 or ASTM A795, threadable, with nonstandard OD and wall thickness less than Schedule 10.

6. Hybrid Steel Pipe: ASTM A135 or ASTM A795, lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5.

7. Schedule 5 Steel Pipe: ASTM A135 or ASTM A795, lightwall.

8. Hot-Dip galvanize in accordance with ASTM A795 coating specifications sprinkler piping and fittings used in dry-pipe systems, exposed to the weather or used in a corrosive atmosphere (where noted on Drawings).

9. Submit mill certificates verifying that the products submitted meet the above criteria.

10. Hot-dip galvanize metallic components of all hangers and supports.

11. As an alternate to solid piping offsets in sprinkler piping drops to attain center of ceiling tile locations, the following flexible system is acceptable:

    a. Provide sprinkler system final connections to the center of ceiling tile by means of an FM approved, braided, stainless steel, one-piece, leak tested flexible pipe drop including a ceiling grid mounting bracket, an adjustable flange and an FM/UL listed sprinkler head as specified. Provide units as manufactured by FlexHead Industries or as approved.

~~C.~~B. Above Ground Fittings:

1. Cast-Iron Threaded Flanges: ASME B16.1.

2. Cast-Iron Threaded Fittings: ASME B16.4.

3. Malleable-Iron Threaded Fittings: ASME B16.3.

4. Steel, Threaded Couplings: ASTM A865.

5. Steel Welding Fittings: ASTM A234, ASME B16.9, or ASME B16.11.

6. Steel Flanges and Flanged Fittings: ASME B16.5.

7. Steel, Grooved-End Fittings: UL-listed and FM-approved, ASTM A47, malleable iron or ASTM A536, ductile iron; with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

8. Steel, Press-Seal Fittings: UL 213 and FM-approved, 175-psig pressure rating; with steel housing, butylene O-rings, and pipe stop; for use with Schedule 5, plain-end, steel pipe. Include UL 45-listed fitting manufacturer's pressure-sealing tools.

~~D. Above Ground Fire Protection Service Valves:~~

~~1. General: UL listed and FM approved, with minimum 175-psig nonshock working pressure rating. Valves for grooved-end piping may be furnished with grooved ends instead of type of ends specified.~~

~~2. Gate Valves, NPS 2 and Smaller: UL 262; cast-bronze, threaded ends; solid wedge; OS&Y; and rising stem.~~

~~3. Indicating Valves, NPS 2-1/2 and Smaller: UL 1091; butterfly or ball-type, bronze body with threaded ends; and integral indicating device.~~

~~4. Visual Indicator: With electrical 115-V ac, prewired, single-circuit, supervisory switch.~~

~~5. Gate Valves, NPS 2-1/2 and Larger: UL 262, iron body, bronze mounted, taper wedge, os&y, and rising stem. Include replaceable, bronze, wedge facing rings and flanged ends.~~

~~6. Indicator Post, Gate Valves: UL 262, iron body, bronze mounted, solid-wedge disc, and nonrising stem with operating nut and flanged ends.~~

7. Indicator Posts: UL 789, horizontal, wall type, cast-iron body, with windows for target plates that indicate valve position, extension rod and coupling, locking device, and red enamel finish.

8. Operation: Operating wrench.

9. Swing Check Valves, NPS 2 and Smaller: UL 312 or MSS SP-80, Class 150; bronze body with bronze disc and threaded ends.

10. Swing Check Valves, NPS 2-1/2 and Larger: UL 312, cast-iron body and bolted cap, with bronze disc or cast-iron disc with bronze disc ring and flanged ends.

11. Split-Clapper Check Valves, NPS 4 and Larger: UL 312, cast-iron body with rubber seal, bronze-alloy discs, and stainless-steel spring and hinge pin.

12. Drain & test valves need not be OS&Y.

2.2 REDUCED PRESSURE BACK FLOW PREVENTER ASSEMBLY

A. Provide UL/FM-approved assembly consisting of two independent "Y" configured check valves and one differential relief valve incorporating two diaphragms separated by a leak indicating spacer.

B. Fabricate internal metal parts included in the check assemblies of Series 300 stainless steel, and not containing dissimilar metals. Fabricate elastomeric seat discs on the check and relief valve to be reversible and seat rings of ASTM B61 bronze, or Series 300 stainless steel. Fabricate the check assembly to be center stem guided at the seat ring and at the cover by replaceable non-corrosive bushings. Fabricate relief valve spring of Series 300 stainless steel.

C. Maximum head losses through the assembly: 12.5 psi at velocities from zero up to and including 7.5 fps. Document flow curves by independent laboratory testing.

D. Include flanged, UL/FM full port, resilient wedge, OS&Y shut-off valves and four vandal resistant ball valve testcocks, considered integral to the assembly. Factory assemble and backflow test the assemblies.

E. Febco 860, Conbraco 40-200, Cla-Val-Co RP-4, or Watts 909/995.

2.3 SINGLE DETECTOR CHECK VALVE ASSEMBLY

A. Provide UL/FM approved single detector check valve assembly consisting of a single check valve with a resilient clapper seat and tinned seat ring with a pre-formed copper tubing by-pass complete with pre-assembled brass fittings, angle stop and dual check valves and provided with the appropriate water meter.

B. Mueller Model A-2132-6, Watts Model 07 or Zurn/Wilkins Model 910DA.

2.4 WATER FLOW SWITCHES

A. Provide UL-listed or FM-approved water flow type switches and/or water pressure type flow switches of the vane type design as shown and where required, compatible with the pipe size and pipe material utilized.

B. Provide switches with an adjustable retard feature.

C. Provide switches with single or double-pole, double throw contacts rated at 1.0 amps, 120 volts, 60 hertz ac and 0.25 amps, 24 volts, dc. Coordinate with related Division 22 sections of the Specifications to determine the exact electrical requirements of the flow switches to ensure their compatibility with the fire alarm system.

D. Provide switches with a tamper switch on the wiring compartment cover plate.

E. Provide switches rated for a minimum of 250 psi working pressure.

F. Provide explosion-proof switches in hazardous areas.

G. Provide switches with an addressable module.

H. Wiring of switches into the fire alarm system is specified elsewhere in Division 21 sections of the Specifications.

I. Provide switches at the following locations:

1. In the sprinkler/standpipe riser as part of the alarm valve trim.

2. Adjacent to each sprinkler zone control valve.

2.5 SUPERVISORY TAMPER SWITCHES

A. Provide UL listed and FM approved supervisory tamper switches on all manually operated valves whose position could impair any part or all of sprinkler system operation.

B. Provide switches with single or double-pole, double-throw contacts rated at 1.0 amps, 120 volts, 60 hertz, ac and 0.25 amps, 24 volts dc. Coordinate with Division 28 sections of the Specifications to determine the exact electrical requirements of the supervisory tamper switches to ensure their compatibility with the fire alarm system.

C. Provide switches with a gasketed, watertight wiring compartment coverplate.

D. Wiring of switches into the fire alarm system is specified elsewhere in Division 21 sections of the Specifications.

E. Provide supervisory tamper switches on any of the following type valves:

1. Post indicator valves (piv) *

2. Outside screw and yoke (os&y) valves.

3. Butterfly valves

4. Plug valves

5. Lever-operated ball valves.

** Post indicator valves shall have an indicator, visible through an opening in the post that shows whether the valve is opened or closed.*

2.6 ALARM VALVE

A. Provide a UL-listed and FM-approved alarm check valve, rated at a minimum of 300 psig working pressure, capable of being installed vertically or horizontally. Provide valve body of ductile iron with flanged or grooved connections. Provide valve with a brass seat, and single hinge pin and latch design. Provide variable pressure trim set with retard chamber, drain connections, pressure gauges, and connections for water motor gong alarm. Do not discharge the drip cup assembly into the main drain piping. The Viking Corp. "Model J-1", or as approved.

2.7 FIRE DEPARTMENT CONNECTIONS

A. Wall, Fire Department Connections:

1. UL 405; cast-brass body with brass, wall, escutcheon plate; brass, lugged caps with gaskets and brass chains; and brass, lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with

pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking "AUTO SPKR & STANDPIPE."

2. Type: Exposed, projecting mounting.

3. Escutcheon Plate: Rectangular.

4. Finish: Polished brass.

B. Exposed, Freestanding, Fire Department Connections:

1. UL 405, cast brass body, inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, and bottom outlet with pipe threads. Include brass, lugged caps, gaskets, and brass chains; brass, lugged swivel connection and drop clapper for each hose connection inlet; 18 inch high brass sleeve; and round, floor, brass, escutcheon plate with marking "AUTO SPKR & STANDPIPE."

2. Finish Including Sleeve: Polished brass.

2.8 ELECTRIC MOTORS

A. General: All motors (except as noted) shall conform to the following specifications:

1. Comply with requirements in this Section except when stricter requirements are specified in fire suppression equipment schedules or sections.
2. 1/2 hp and Small: Single phase.
3. Larger than 1/2 hp shall be three phase, except where specifically noted otherwise
4. Comply with NEMA MG 1 unless otherwise indicated.

B. Motor Characteristics:

1. Duty: Continuous duty at ambient temperature of 40 C and at site elevation.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designed speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors:

1. Description: General purpose NEMA MG 1, Design B, except “C” where required for high starting torque, medium induction motor.
2. NEMA Premium Efficiency, as defined in NEMA MG 1 when available, otherwise energy efficient.
3. Service Factor: 1.15.
4. Multi-speed Motors: Separate winding for each speed.
5. Rotor: Random wound, copper windings, squirrel cage.
6. Bearings:
   a. Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading, minimum 40,000 hour L-10 life.
   b. Sleeve type bearings are permitted for fractional horsepower and light-duty motors.
7. Code Letter Designation:
   a. Motors 15 hp and Larger: NEMA starting Code F or Code G.
   b. Motors Smaller than 15 hp: Manufacturer’s standard starting characteristic.
8. Enclosure
   a. Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

b. Open drip-proof motors for indoor use where satisfactorily housed and properly ventilated during operation.
c. Weather protected Type I for outdoor use when enclosed or housed with adequate ventilation, or TEFC when exposed to weather or moist locations.
d. Special enclosures required for hazardous areas (explosion-proof, etc.) per equipment schedules. Explosion-proof motors shall be UL listed.

9. Motor Selection Criteria:
a. Motor size shall be large enough so that the driven load will not require the motor to operate above 80% of its rated horsepower. Minimum horsepower ratings are shown or scheduled on the drawings.
b. Pump motors shall be "non-overloading"; i.e. shall not operate in service factor at any point on pump curve.

D. Polyphase Motors with Additional Requirements:

1. Motors Used with Reduced Voltage and Multi-speed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
a. 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.
b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

E. Single Phase Motors:

1. Motors shall be one of the following, to suit starting torque and requirements of specific motor application:
a. Permanent-split capacitor.
b. Spilt phase.
2. Multi-speed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. 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.

2.9 POWER FACTOR CORRECTION

A. Capacitors shall be installed on all motors 25 hp and larger that have an uncorrected power factor of less than 90% at rated load. KVAR size shall be as required to correct motor power factor to 95% lagging.

B. Capacitors shall have:

1. Individual unit cells
2. All welded steel housings
3. Non-flammable synthetic liquid impregnant
4. Craft tissue insulation

5. Aluminum foil electrodes

C. Each capacitor shall be internally fused.

2.10 MOTOR CONTROLLERS

A. General Motor Controller Characteristics:

1. Single speed and multi-speed motor controllers shall be combination type [full NEMA rated] [IEC][NEMA Equivalent] starters with [motor circuit protector][fused or non fused][disconnect switch] for all motors provided.

Exception: Starters that are shown to be provided integral within packaged equipment, control panels with door mounted disconnects or in motor control centers

2. All combination starters shall be adequately braced for the fault current available. [42,000 AIC @ 480V, three phase and 65,000 AIC @ 208V, three phase shall be the minimum ratings.] All starters, whether separately furnished or integral with equipment, shall comply with the following:

a. Enclosures: NEMA Type 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA Type 3R with conduit hubs, or units in hazardous locations that shall have NEC proper class and division explosion proof enclosure.

b. All starters for three-phase motors shall be magnetic complete with the following accessories.

1) Three leg Class 10 trip free electronic overload protection with externally operated manual reset and visual trip indicator. Trip setting shall be adjustable with locking cover.

2) Built in three phase voltage monitor to provide quick trip on single phasing, phase reversal, or high/ low voltage, manual reset.

3) Control transformers with fused primary and secondary per NEC.

4) 120 volt holding coils.

5) Integral Hand-Off-Auto switch for single speed motors.

6) Integral High-Low-Off-Auto switch for two speed starters.

7) High to low speed compelling time delay relay for two speed starters.

8) Auxiliary contacts, one normally open and one normally closed minimum.

9) "Run" pilot light.

2.112.2 INDENTIFCATION

A. Equipment Labels:

1. Metal Labels for Equipment:

a. Material and Thickness: Brass, 0.032 inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

b. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

c. Minimum Letter Size: 1/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

d. Fasteners: Stainless-steel rivets or self-tapping screws.

e. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2. Plastic Labels for Equipment:

a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

b. Letter Color: White

c. Background Color: Black or blue.

~~d. Maximum Temperature: Able to withstand temperatures up to 160 ºF.~~

~~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: Contract-type permanent adhesive, compatible with label and with substrate.~~

~~3. Label Content: Include equipment's unique equipment number, Drawings numbers where equipment is indicated (plan, details, and schedules).~~

~~4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) 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.~~

~~B.~~A. Pipe Labels:

1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
2. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and t attach to pipe without fasteners or adhesive.
3. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
4. 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.
   a. 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.
   b. Lettering Size: At least 1-1/2 inches high.

~~C.~~B. Stencils:

1. Stencils: Prepare with letter sizes according to ASME A 13.1 for piping; minimum letter height of 2 inches for equipment labels, and similar operational instructions.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior enamel in colors according to ASME A13.1 unless otherwise indicated.

~~D.~~C. Valve Tags:

1. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   a. Tag Materials: Brass, 0.032-inch minimum thickness, and having pre-drilled or stamped holes for attachment hardware.
2. Valve Schedules: For each piping system, on 8-/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 or closed), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   a. Valve-tag schedule shall be included in operation and maintenance data.

~~2.12~~2.3 ACCESSORIES

A. Hangers and Supports: Furnish hangers and supports in accordance with Divisions 22 and 23 sections of the Specifications.

B. Sleeves and Cover Plates (Escutcheons):

1. Sleeves:
   a. Galvanized Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joints.
   b. Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.
   c. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.

2. 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 cover opening.
   a. One-Piece, Deep-Pattern Type: Deep-drawn, box shaped brass with polished chrome plated finish.
   b. Spit-Casting, Cast Brass Type: With concealed hinge and set screw. Finish: Polished chrome plated.
   c. One-Piece, Floor-Plate Type: Cast-ion floor plate.
   d. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.
   e. Split-Casting, Cast Brass Type: With concealed hinge and set screw. Finish: Polished chrome plated
   f. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

~~C. Antifreeze System:~~

~~1. Provide an antifreeze system serving sprinklers in loading docks and in other unheated areas as specified on the drawings.~~

~~2. Design the antifreeze system in accordance with NFPA 13.~~

~~3. Solution mixture: ethylene glycol with a solution mixture of 60 percent water suitable for -10°F, or as required.~~

~~4. Provide a chain and lock for the antifreeze system gate valve and the key to the Owner.~~

~~D.~~C. Pressure Gages:

1. Provide pressure gages on the suction and discharge sides of the fire pump.
2. Provide pressure gages on both sides of the wet pipe sprinkler system alarm valve and at the top of each standpipe riser.
3. Provide UL-listed spring pressure gages with a 3-1/2-inch dial and be drainable.
4. Provide any additional gauges required by NFPA 13, 14 and 20, not specifically listed here.

~~E.~~D. Inspectors Test Connection and Drains:

1. Provide an inspectors test connection and drain system (riser and low point drain) in accordance with NFPA 13 for each zone.
2. Provide a sectional drain valve and common drain piping to the nearest floor drain for drainage.
3. Provide a test valve, sight glass, sprinkler orifice equivalent and piping trim to the common drain piping for system testing.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article in Part 1 of this section of the Specifications.

B. Report test results promptly and in writing.

3.2 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PIPING APPLICATIONS

A. Do not use welded joints with galvanized steel pipe.

B. Flanges, unions, and transition and special fittings with pressure ratings the same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

C. Piping between Fire Department Connections and Check Valves: Use galvanized, standard-weight steel pipe with threaded ends; cast- or malleable-iron threaded fittings; and threaded joints

3.4 JOINT CONSTRUCTION

A. Steel-Piping, Grooved Joints: Use Schedule 40 steel pipe with cut or roll-grooved ends and Schedule 30 or thinner steel pipe with roll-grooved ends; steel, grooved-end fittings; and steel, keyed couplings. Assemble joints with couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions. Use gaskets listed for dry-pipe service for dry piping.

B. Copper-Tubing, Grooved Joints: Use copper tube with roll-grooved ends; copper, grooved-end fittings; and copper, keyed couplings. Assemble joints with couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions. Use gaskets listed for dry-pipe service for dry piping.

C. Brazed Joints: Use AWS A5.8, BCuP-3 or BCuP-4 filler metals.

D. Mechanically Formed, Copper-Tube-Outlet Joints: Use UL-listed tool and procedure and follow forming equipment manufacturer's written instructions. Drill pilot hole in copper tube, form branch for collar, dimple tube to form seating stop, and braze branch tube into formed-collar outlet.

E. Press-Seal-Fitting Joints: Use UL-listed tool and procedure and follow fitting manufacturer's written instructions. Include use of specific equipment, pressure-sealing tool, and accessories.

F. Locking-Lug-Fitting, Twist-Locked Joints: Follow fitting manufacturer's written instructions.

G. Dissimilar-Piping-Material Joints: Construct joints using adapters or couplings compatible with both piping materials. Use dielectric fittings if both piping materials are metal. See Divisions 22 and 23 sections of the Specifications for dielectric fittings.

H. Handling of Cleaners, Primers, and Solvent Cements for CPVC Pipe: Comply with procedures in ASTM F 402 for safe handling when joining CPVC piping with solvent cements.

I. Welding:

1. General: Shop welding of steel piping is permitted for automatic sprinkler systems in lieu of screwed or flanged fittings. Join steel pipe for installation by means of screwed fittings, flanged fittings or by mechanical grooved couplings. Field welding or torch cutting is not permitted.

2. Welded Fittings:

a. Provide welded fittings in compliance with ASME B16.9 for factory made wrought steel buttweld fittings, and ASTM A234 for piping fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures.

b. Factory fabricated reinforcing saddles with threaded outlets shall be permitted provided the outlet size does not exceed 1/2 of the pipe diameter and the fittings are shop welded only.

3.5 WELDER QUALIFICATIONS AND PROCEDURES: SPECIFICATIONS FOR THE FABRICATION AND ERECTION OF PIPING SYSTEMS

A. Piping: ANSI B31.1.

B. Boiler external piping: Section I of the ASME Boiler and Pressure Vessel Code.

C. Before any welding is performed, submit a copy of the standard welding procedure specification together with the procedure qualification record as required by Section IX of the ASME Boiler and Pressure Vessel Code.

D. Welders of stainless steel tubing shall be qualified in the Tungsten inert gas (TIG) method of welding.

E. Before any welder shall perform any welding, submit a copy of the Contractor's record of welder or welding operator qualification tests as required by Section IX of the ASME Boiler and Pressure Vessel Code. Requalify welders who have been inactive with the welding process for a period of more than three months, or six months if allowed by the particular code for which their qualifications are being reviewed.

F. The types and extent of non-destructive examinations required for pipe welds are as shown in table 136.4 of ANSI B31.1. If requirements for non-destructive examinations are to be other than that stated above, the degree of examination and basis of rejection shall be a matter of prior written agreement between the fabricator, or Contractor and the purchaser. Qualifications for non-destructive testing personnel shall be as established by the American Society for Nondestructive Testing in their recommended practice No. SNT-TC-1A.

1. Welding inspectors shall meet requirements of AWS QC1.

2. The manufacturer or Contractor shall be responsible for the quality of welding done by his organization and shall repair or replace any work not in accordance with these Specifications.

3. Welding done to fabricate structures other than piping and vessels shall conform to the requirements of AWS D1.1.

3.6 PIPING INSTALLATION

A. See Divisions 22 and 23 sections of the Specifications for basic piping installation requirements.

B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

C. Do not route any fire suppression piping through electrical rooms except for the piping serving sprinkler heads in those rooms. Install piping and sprinkler heads in electrical rooms in accordance with NFPA 13 and NFPA 70.

~~D. Install underground service-entrance piping according to NFPA 24 and with restrained joints.~~

~~E.~~D. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

~~F.~~E. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

~~G.~~F. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.

~~H.~~G. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve, sized and located according to NFPA 13.

~~I.~~H. Install sprinkler piping with drains for complete system drainage.

~~J.~~I. Install sprinkler zone control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

~~K.~~J. Install drain valves on standpipes.

~~L.~~K. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.

~~M.~~L. Install alarm devices in piping systems.

~~N.~~M. Hangers and Supports: Comply with NFPA 13 for hanger materials. Install according to NFPA 13 for sprinkler piping and to NFPA 14 for standpipes.

~~O.~~N. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage.

~~P.~~O. Install piping with grooved joints according to manufacturer's written instructions. Construct rigid piping joints, unless otherwise indicated.

~~Q.~~P. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

3.7 VALVE INSTALLATION

A. See Divisions 22 and 23 sections of the Specifications for installing general-duty valves. Install fire-protection specialty valves, trim, fittings, controls, and specialties according to NFPA 13 and NFPA 14, manufacturer's written instructions, and authorities having jurisdiction.

B. Gate Valves: Install fire-protection-service valves supervised-open, located to control sources of water supply except from fire department connections. Provide permanent identification signs indicating portion of system controlled by each valve.

~~C. Valves for Wall Fire Hydrants: Install gate valve with nonrising stem in supply pipe.~~

~~D. Install check valve in each water supply connection. Install backflow preventers instead of check valves in potable water supply sources.~~

~~E. Alarm Check Valves: Install valves in vertical position for proper direction of flow, including bypass check valve and retard chamber drain line connection.~~

3.8 FIELD QUALITY CONTROL

A. Testing:

1. General:

   a. Test piping in accordance with NFPA 13 and 14 for aboveground piping and NFPA 24 for underground piping.

   b. Submit the request for formal inspection to the Owner at least five working days prior to the date of the inspection. Inspect the system, including actual operation of all mechanical and electrical equipment, in the presence of a competent representative of the Contractor and other required authorities.

   c. Be responsible for supplying all appliances and equipment required for satisfactorily testing the system.

   d. Perform tests before piping is concealed.

2. Test Conditions:

   a. When connecting to piping previously installed and subjected to testing under this Contract, extend the test pressure and joint count to the nearest workable valve on the line.

   b. When connecting to piping not installed or tested under this Contract, the Contractor is responsible for the integrity of piping to a distance of three feet beyond the connection point ten feet for underground pipe). Should an existing fitting be located between the point of connection and limit of ten feet, the Contractor's responsibility shall be increased an additional ten feet in all directions from the center of the fitting.

   c. Should the existing piping fail beyond the limits stated above, the Owner shall be responsible for repairs.

3. Flow Tests:

   a. Test piping hydrostatically at not less than 200 psi for two hours or at 50 psi in excess of the maximum static pressure when the maximum static pressure is in excess of 150 psi.

   b. Aboveground pipe shall show no visible signs of leakage when subjected to hydrostatic test pressures.

   ~~c. Measure the amount of leakage for underground piping at the specified test pressure by pumping from a calibrated container. Maximum amount of leakage at the joints: two quarts per hour per 100 gaskets or joints regardless of pipe diameter.~~

   ~~d.~~c. The amount of allowable leakage specified may be increased by one fluid ounce per inch valve diameter per hour for each metal seated valve isolating the test section.

   ~~e. Backfill trenches for underground pipe between joints before testing to prevent movement of pipe.~~

~~f. Foam System Testing: In testing of the foam system, perform an immediate on site analyses of foam quantity by use of a portable refractometer as well as obtaining foam samples for testing by an independent laboratory. Submit test results to the Architect and the Owner.~~

4. Test Reports:

   a. Perform field inspections and tests to determine conformance with the specified requirements in the presence of the Architect and Owner.

   b. When tests have been completed and all necessary corrections made, submit a signed and dated performance certificate, record drawings and full descriptive data for each tested system in this section including operation and maintenance manuals.

   c. For water distribution systems (aboveground and underground), provide the Owner with three copies of each of the following:

      1) Hydrostatic test certificate

      2) Flow/pressure test certificate

      3) Flushing certificate

3.9 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers having paint other than factory finish.

3.10 PROTECTION

A. Protect sprinklers from damage until Substantial Completion.

3.11 LABELING AND IDENTIFICATION

A. Install labeling and markers on equipment and piping according to the requirements of NFPA 13 and 14, ANSI 13.1 and Divisions 22 and 23 sections of the Specifications.

3.12 COMMISSIONING

A. Verify that specialty valves, trim, fittings, controls, and accessories are installed and operate correctly.

B. Verify that specified tests of piping are complete.

C. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.

D. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and have guards as required for each application.

E. Verify that potable-water supplies have correct types of backflow preventers.

~~F. Verify that hose connections and fire department connections have threads compatible with local fire department equipment.~~

~~G.~~F. Fill wet-pipe sprinkler piping with water.

~~H. Energize circuits to electrical equipment and devices.~~

~~I.~~G. Adjust operating controls and pressure settings.

~~J.~~H. Coordinate with fire alarm tests. Operate as required.

3.13 DEMONSTRATION

A. Demonstrate equipment, specialties, and accessories. Review operating and maintenance information.

B. Schedule demonstration with Owner with at least seven days' advance notice.

END OF SECTION 210500

SECTION 210548
VIBRATION CONTROLS FOR FIRE-SUPRESSION 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes extent of vibration control work required by this Section is indicated on drawings and schedules, and/or specified in other Division 21 sections of the Specifications.

B. Types of vibration control products specified in this Section include the following:

1. Neoprene Pads.
2. Vibration Isolation Springs.
3. ~~Pad-Type Isolators.~~
4. ~~4.~~3. Neoprene Mountings.
5. ~~5.~~4. Spring Isolators, Freestanding.
6. ~~Roof Curb Isolators.~~
7. ~~7.~~5. Isolation Hangers.
8. ~~8.~~6. Flexible Pipe Connectors.

1.3 REFERENCES

A. Applicable Standards:

1. American National Standards Institute (ANSI).
2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

1.4 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.

1.5 SUBMITTALS

A. General: Submit the following in accordance with requirements elsewhere in Division 21.

1. Product Data: Submit manufacturer's technical product data and installation instructions for each type of vibration control product. Submit schedule showing size, type, deflection, and location for each product furnished.
2. Maintenance Data: Submit maintenance data for each type of vibration control product. Include this data, product data, and shop drawings in maintenance manual, in accordance with requirements of Division 1.

1.6 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products, or type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than five years.

1. Except as otherwise indicated, obtain vibration control products from single manufacturer.
2. Engage manufacturer to provide technical supervision or installation of vibration control products.

PART 2 - GENERAL

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide vibration control products of one of the following:

1. Amber/Booth Co.
2. Korfund Dynamics Corp.
3. Mason Industries, Inc.
4. Peabody Noise Control, Inc.
5. Vibration Eliminator Co., Inc.
6. Vibration Mountings and Controls, Inc.

2.2 MATERIALS

A. Neoprene Pads: Oil-resistant neoprene sheets, of manufacturer's standard hardness and cross-ribbed or waffled pattern.

B. Vibration Isolation Springs: Wound-steel compression springs, of high-strength spring alloy steel, with spring diameter not less than 0.8 of compressed height of spring at rated loads. Provide minimum additional travel to solid, equal to 50% of rated deflection. Provide spring wire with elastic limit stress exceeding stress at solid deflection.

~~C. Pad-Type Isolators: Except as otherwise indicated, provide manufacturer's standard pad-type isolation unit, fiberglass pads or shapes, or neoprene pads.~~

~~D.~~C. Neoprene Mountings: Provide neoprene mountings consisting of neoprene element bonded between two steel plates that are neoprene-covered to prevent corrosion. Provide minimum rated deflection of 0.35-inch. Provide threaded hole in upper plate and two holes in base plate for securing to equipment and to substrate.

~~E.~~D. Spring Isolators, Freestanding: Except as otherwise indicated, provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with locknuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.

1. Include holes in bottom plate for bolting unit to substrate as indicated.

~~F. Roof-Curb Isolators: Fabricated frame units sized to match roof curbs as shown, formed with isolation springs between extruded aluminum upper and lower sections, which are shaped and positioned to prevent metal-to-metal contact. Provide continuous airtight and waterproof seal between upper and lower extrusions. Include provisions for anchorage of frame unit to roof curb, and for anchorage of equipment unit.~~

~~G.~~E. Isolation Hangers: Hanger units formed with brackets and including manufacturer's standard compression isolators of type indicated. Design brackets for three times rated loading of units. Fabricate units to accept misalignment of 15 degrees off center in any direction before contacting

hanger box, and for use with either rod or strap type members, and including acoustical washers to prevent metal-to-metal contacts.

1. Provide vibration isolation spring with cap in lower part of hanger and rubber hanger element in top, securely retained in unit.
2. Provide neoprene element, with minimum deflection of 0.35-inch, securely retained in hanger box.
3. Provide fiberglass pad or shape, securely retained in unit, with threaded metal top plate.
4. Provide hangers, precompressed to rated load to limit deflection during installation. Design so hanger may be released after full load is applied.

~~H.~~F. Flexible Pipe Connectors:

1. For nonferrous piping, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.
2. For ferrous piping, provide stainless steel hose covered with stainless steel wire braid with NPT steel nipples or 150 psi ANSI flanges, welded to hose.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION

A. General: Except as otherwise indicated, select vibration control products in accordance with ASHRAE Handbook, 2007 HVAC Applications Volume, Chapter 47 "Sound and Vibration Control," Table 48. Where more than one type of product is offered, selection is Installer's option.

B. Piping: For piping connected to equipment mounted on vibration control products, install isolation hangers as indicated, and for first 3 points of support for pipe sizes 4 inches and less, for first 4 points of support for pipe sizes 5 inches through 8 inches, and for first 6 points of support for pipe sizes 10 inches and over.

3.3 ERECTION INSTALLATION APPLICATION

A. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

D. Locate isolation hangers as near overhead support structure as possible.

E. Weld riser isolator units in place as required to prevent displacement from loading and operations.

F. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.

3.4 ADJUSTING

A. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated.

3.5 CLEANING

A. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.6 DEMONSTRATION

A. General: Comply with minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units as indicated.

B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units.

END OF SECTION 210548

SECTION 211300
FIRE-SUPPRESSION

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 SUMMARY

A. This Section includes the design and provision of the wet-pipe sprinkler fire suppression system.

1.3 REFERENCES

A. National Fire Protection Association (NFPA)

1. 13 - Installation of Sprinkler Systems.
2. 13R - Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.
3. 14 - Installation of Standpipe, Private Hydrant, and Hose Systems
4. 30 - Flammable and Combustible Liquids Code.
5. 70 - National Electrical Code.
6. 230- Storage Fire Protection of.

B. Underwriters Laboratories Inc. (UL)

1. Fire Protection Equipment Directory.
2. 199 – Automatic Sprinklers for Fire-Protection Service.
3. 1626 – Residential Sprinklers for Fire-Protection Service.
4. 1767 – Early-Suppression Fast-Response Sprinklers.

1.4 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. High-Pressure Piping System: Fire-suppression piping system designed to operate at working pressure higher than standard 175 psig (1200 kPa).

D. PE: Polyethylene plastic.

E. Underground Service-Entrance Piping: Underground service piping below the building.

1.5 SYSTEMS DESCRIPTION

A. Design Requirements: Design and provide a wet-pipe sprinkler fire suppression system that satisfies the applicable Building Code definition of a fully sprinklered building, in complete compliance with NFPA 13 and meeting the approval of the Authority Having Jurisdiction (AHJ).

B. Design Criteria:

1. Hydraulically design the sprinkler system to Ordinary Hazard Group 2 in accordance with NFPA 13.
2. Provide a sprinkler system which is incorporated with the standpipe system and defined as "combined" for water supply and hydraulic calculation purposes.

a. Standpipe system components, in accordance with NFPA 14, shall be rated for working pressures not less than the maximum pressure to be developed at their corresponding locations within the system under any conditions including the pressure that occurs when the system is connected to the fire apparatus (pumper truck) of the AHJ.

3. Provide fire protection zones as indicated on the Drawings.

4. Calculate the system demand to the water main tap.

5. Submit an isometric diagram and a graph showing water supply vs system demand with the hydraulic calculations.

6. System water demand pressure: a minimum of 10 psig below the water supply pressure.

7. Minimum pressure at the most remote standard sprinkler head: 7 psi.

8. C-factors for calculating friction loss in pipe:

   a. 120 for steel pipe.

   b. 140 for lined ductile iron pipe.

   c. 100 for unlined ductile iron pipe.

9. Do not exceed the following velocities in piping:

   a. Underground piping - 6 feet/second.

   b. Aboveground piping - 24 feet/second.

10. Secure and be responsible for the measurements of the system.

11. Show nozzle identification and "K" factor, gpm, pipe sizes, pipe and equivalent fitting lengths, elevation, friction loss, pressure summary including velocity pressure, adjusted flow and velocities in fps on calculation sheets.

1.6 SYSTEM PERFORMANCE REQUIREMENTS

A. Design sprinklers and obtain approval from authorities having jurisdiction

B. Design sprinkler piping according to the following and obtain approval from authorities having jurisdiction:

1. Include 10 percent margin of safety for available water flow and pressure.

~~2. Include 20 percent margin of safety for available water flow and pressure.~~

~~3.~~2. Include losses through water-service piping, valves, and backflow preventers.

~~4.~~3. Minimum Density for Automatic-Sprinkler Piping Design – All Areas: As follows:

   a. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.

~~5.~~4. Maximum Protection Area per Sprinkler: As follows:

   a. Office Space: 130 sq. ft.

   b. Storage Areas: 130 sq. ft.

   c. Mechanical Equipment Rooms: 130 sq. ft.

   d. Electrical Equipment Rooms: 130 sq. ft.

   e. Other Areas: 130 sq. ft.

C. Components and Installation: Capable of producing piping systems with 175-psig minimum working-pressure rating, unless otherwise indicated.

1.7 SUBMITTALS

A. See Division 1 sections of the Specifications for submittal requirements and for product options and substitutions.

B. Submit manufacturer's data sheets on all system components, including the following:

1. Sprinkler heads
2. Cabinets
3. Valves
4. ~~Fire Department inlets~~
5. ~~4.~~ Accessories

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has designed and installed fire-suppression piping similar to that indicated for this Project and obtained design approval and inspection approval from authorities having jurisdiction.

B. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer. Base calculations on results of fire-hydrant flow test.

C. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of fire-suppression piping that are similar to those indicated for this Project in material, design, and extent.

D. Manufacturer Qualifications: Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in the UL Fire Protection Equipment Directory and FM Fire Protection Approval Guide and that comply with other requirements indicated.

E. Sprinkler Components: Listing/approval stamp, label, or other marking by a testing agency acceptable to authorities having jurisdiction.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

G. NFPA Standards: Equipment, specialties, accessories, installation, and testing complying with NFPA 13, 13R, 14, and 230.

1.9 WARRANTY

A. General:

1. Submit special warranties for the products so specified elsewhere in Division 21 sections of the Specifications.
2. Submit statements of compliance for the products so specified elsewhere in Divisions 2 and 21 sections of the Specifications.

~~1.10 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. Sprinkler Cabinets: Finished, wall-mounting steel cabinet and hinged cover, with space for a minimum of six spare sprinklers plus sprinkler wrench. Include the number of sprinklers required by NFPA 13 and wrench for sprinklers. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.~~

PART 2 - PRODUCTS

2.1 GENERAL

A. See requirements of Division 21 sections of the Specifications related sections.

2.2 SPRINKLERS

A. Automatic Sprinklers: With heat-responsive element complying with the following.

1. UL 199, for applications except residential.
2. UL 1626, for residential applications.
3. UL 1767, for early suppression, fast-response applications.

B. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.

C. Sprinkler types, features, and options include the following:

~~1. Concealed ceiling sprinklers, including cover plate~~

~~2. Extended coverage sprinklers~~

~~3. Flush ceiling sprinklers, including escutcheon~~

~~4.~~1. Pendent sprinklers

~~5. Pendent, dry-type sprinklers~~

~~6. Recessed sprinklers, including escutcheon~~

~~7. Sidewall sprinklers~~

~~8. Sidewall, dry-type sprinklers~~

~~9. Sidewall concealed sprinklers~~

~~10. Upright sprinklers~~

D. Flexibly Piped Sprinkler Heads: FM approved and UL listed, ceiling mounted, pendent sprinkler heads with an attached, flexible, 300 PSI rated, stainless steel hose in 2 – 6 foot lengths, as manufactured by FlexHead Industries, may be employed in lieu of the specified heads where so indicated on the Drawings.

~~E. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.~~

~~F.~~E. Provide automatic type; pendant, upright or sidewall as shown or required, sprinkler heads of the manufacturer's standard product.

~~G.~~F. Where indicated, provide UL-listed, extended coverage sprinkler heads.

~~H.~~G. Provide standard or quick response sprinklers as noted on the Drawings or required by the applicable code for the specific use or requirements.

~~I. In all areas without suspended ceilings, provide upright, brass sprinkler heads with the appropriate temperature ratings.~~

~~J.~~H. In office and public areas with suspended ceilings, provide concealed type pendant heads with the appropriate temperature ratings. Color: same as ceiling.

~~K.~~I. In other areas with suspended ceilings provide recessed pendant type heads with chrome escutcheon of appropriate temperature heading.

~~L. Provide dry pendant sprinklers in areas subject to temperatures of 40 degrees F or less.~~

~~M.~~J. In the vicinity of heating diffusers, unit heaters, boiler and heater rooms and other high ambient temperature areas, provide sprinkler heads having a temperature rating relative to those temperature conditions as determined by NFPA 13.

~~N. Provide corrosion proof sprinkler heads where corrosive conditions exist.~~

~~**2.3 EQUIPMENT**~~

~~A. Fire Department inlet (FDC): Provide free standing 2-way Fire Department inlet connection. Unit shall be cast brass body, chrome plated and have identification base plate, caps and chains chrome plated. UL Listed, Potter Roemer Model 5761-D or approved equal.~~

~~B.Fire Hose Valves:~~

~~1. Fire Hose Valve (FHV-1) cast brass valve with red hand wheel, male hose threads with cap and chain. Unit shall be rough chrome plated finish, UL Listed. Potter Roemer Model 4065-C with 4625-C or approved equal.~~

~~2. Fire Hose Valve (FHV-2) cabinet shall be 20 gauge box, 20 gauge tubular steel door and continuous steel hinge for recessed mounting. Provide with red powder coated finish. Furnish with hose valve same as FHV-1. Potter Roemer Model 1810 with full glass door and 4065 valve and 4625-C cap, or approved equal.~~

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PART 3 - EXECUTION

3.1 GENERAL

A. Comply with requirements of Division 21 related sections.

3.2 SPACING AND LOCATION OF SPRINKLERS

A. Space and locate sprinkler heads in accordance with NFPA 13 and as shown on the Drawings. Locate and install sprinkler heads in accordance with the manufacturer's recommendations to maintain UL listing.

B. Provide uniform spacing of sprinklers on branch lines.

C. Locate sprinkler heads as indicated on reflected ceiling plans and applicable shop drawings. In rooms and spaces with suspended grid ceilings where sprinkler head locations are not indicated, locate sprinkler heads in the center of ceiling tiles in both directions. Locate the sprinkler heads to avoid conflicts with lighting, diffusers, equipment and structural obstructions located in the ceiling.

D. Where sprinkler heads are located by the Contract Documents, their locations have been identified for general coordination with the work of other trades. The sprinkler heads indicated do not quantify the bid. Provide additional sprinkler piping and heads where required for full coverage. Where sprinkler head location criteria indicated or specified require the installation of a greater quantity of heads to achieve full coverage than would otherwise be required, provide the greater quantity of piping and heads.

3.3 PROTECTION OF SPRINKLER HEADS

A. Install wire-cage type sprinkler guards in all stair areas, telecommunications rooms, electrical rooms, janitor's closets and in any other areas where the activity in the space could result in accidental damage to sprinkler heads.

END OF SECTION 211300

SECTION 226113
COMPRESSED AIR PIPING ~~FOR LABORATORY FACILITIES~~

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 SUMMARY

A. See other sections of Division 22 and the Drawings to determine the extent of the required Work.

B. This Section includes compressed-air piping and specialties for ~~nonmedical laboratory facilities, designated "laboratory air,"~~ operating between 50 psig (345 kPa) and 125 psig (860 kPa).

1.3 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. B1.20.1 - Pipe Threads, General Purpose (Inch).
2. B16.3 - Malleable Iron Threaded Fittings.
3. B16.5 - Pipe Flanges and Flanged Fittings.
4. B16.9 - Factory-Made Wrought Steel Buttwelding Fittings.
5. B16.11 - Forged Steel Fittings, Socket-Welding and Threaded.
6. B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
7. B18.2.1 - Square and Hex Bolts and Screws - Inch Series.
8. B18.2.2 - Square and Hex Nuts (Inch Series).
9. B18.22.1 - Plain Washers.
10. B31.3 - Process Piping.
11. B36.10 - Welded and Seamless Wrought Steel Pipe.

B. American National Standards Institute (ANSI)

C. American Society for Testing and Materials (ASTM)

D. American Welding Society (AWS): A5.8 - Specifications for Brazing Filler Metal

E. American Water Works Association (AWWA):

F. Cast Iron Soil Pipe Institute (CISPI): Cast Iron Soil Pipe and Fittings Handbook.

G. Copper Development Association (CDA): Copper Tube Handbook.

H. Factory Mutual (FM): 1680 - Approved Standard for Couplings Used in Hubless Cast Iron Systems for Drain, Waste, or Vent, Sewer, Rainwater or Storm Drain Systems Above and Below Ground, Industrial/Commercial and Residential.

I. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43 - Wrought Stainless Steel Butt-Welding Fittings.

J. National Sanitation Foundation (NSF)

1.4 DEFINITIONS

A. D.I.S.S.: Diameter-index safety system.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.5 SUBMITTALS

A. See Division22 sections of the Specifications.

B. Submit Product Data on the following:

~~1. Underground piping materials.~~

~~2.~~1. Aboveground piping materials.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

~~1. Medical Compressed Air Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.~~

~~2.~~1. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.

~~B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is an NRTL, and that is acceptable to authorities having jurisdiction.~~

~~1. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.~~

~~C.~~B. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections. ~~provided for in Division 22 Section "Gas Piping for Laboratory and Healthcare Facilities."~~

~~D.~~C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

~~E.~~D. 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.

~~F.~~E. ASME Compliance:

1. Comply with ASME B31.1, "Power Piping," for ~~laboratory~~ compressed-air piping operating at more than 150 psig (1035 kPa).
2. Comply with ASME B31.9, "Building Services Piping," for ~~laboratory~~ compressed-air piping operating at 150 psig (1035 kPa) or less.

1.7 WARRANTY

A. See procedures in Division 1 sections of the Specifications.

PART 2 - GENERAL

2.1 ~~LABORATORY~~ COMPRESSED AIR PIPING MATERIALS

A. Piping Materials:

1. Type “L” hard drawn copper tubing with wrought copper, long turn fittings or red brass prep with threaded, red brass, long turn fittings. Solder shall be silver solder (15% silver composition and BCuP5 classification), on all concealed work; 95-5 (tin/antimony) solder on all exposed work.

B. Valve and Specialty Schedule

1. Ball Valves: Bronze, full port, chrome plated bronze ball with reinforced Teflon seats and packing, 400 psi W.O.G. screwed or solder.
2. Butterfly Valves: 2” and smaller: Bronze, stainless steel disc and stem, VITRON seal, 175 psi working pressure, 350 psi W.O.G., 29” Hg vacuum, screwed or solder.
3. Unions: 300 lb. W.O.G. cast bronze or brass flanges.
4. Dielectric Unions: Unions rated for 250 psi with galvanized or plated steel threaded end, copper solder end and impervious isolation gasket approved for use on gas, oil, air and water lines. Flanges to be complete with insulated bolt sleeves, washers and gaskets.
5. Pressure Gauges: 3” minimum dial, bronze bourdon tube with ¼” pipe thread bottom mount, steel case, white face with black lettering, screwdriver calibration. Accuracy to be 1% of full scale or better. Pressure ranges to be approximately double the expected working pressure of the service. Brass lever handled cock and pigtail. U.S. Gauge figure 5801, Trerice 600C, Danton 101 or equivalent, by Ashcroft, Dwyer, Foxboro, Marsh, Marshalltown, Mueller Brass, Merian or Weiss.
6. Quick Couplers: Automatic ½” one-way shut-off safety coupler. Foster, Amflo, Quincy.
7. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated, relieving type; manual pressure-setting adjustment; rated for 250 psig minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10 psig inlet pressure. Matheson Model 18 Series or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine rough-in requirements for plumbing fixtures and other equipment having to verify actual locations of piping connections prior to installation.
2. Examine walls, floors, roofs, and plumbing chases for suitable conditions where piping and specialties are to be installed.
3. Piping shall be run true, plumb, and straight, with all restraints adjusted to carry their proportional load and locked to prevent pipe “wag,” misalignment, movement, shear, or sagging.
4. Use fittings for all changes in direction and all branch connections.
5. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted unless expressly indicated.
6. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications. Piping hanger spacing and supports shall be per Code requirements (minimum). ~~or per Division 22, “Hangers and Supports for Plumbing Piping and Equipment,” whichever is more stringent.~~

7. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors unless indicated to be exposed to view.

8. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Allow sufficient space above removable ceiling panels to allow for panel removal.

9. Fire Barrier Penetrations: Where pipes pass through fire-rated walls partitions, ceilings, and floors, maintain the fire-rated integrity. Use fire-stop caulking materials at all fire-rated wall penetrations.

10. Provide for pipe expansion and seismic braces as required by the contract documents and/or jurisdictional authority.

11. All copper tube and fitting shall be reamed and buffed prior to soldering or brazing.

12. The use of solder containing lead is prohibited.

13. Refer and conform to the "Copper Development Association" instructions for proper preparation and actual installation practice for all soldered and brazed joints.

B. ~~Laboratory~~ Compressed Air ~~and Vacuum~~ Piping

1. General

   a. Pitch all mains back to the central system and provide valved drain pockets and drain cocks at all low points and trapped sections in the system.

   b. Connect all branches to the top of mains. Valve all risers and branches.

   c. Use Y or TY fittings where tees are shown on drawings (2 ½" or larger).

2. Cleanouts: Install full size cleanouts at the end of each main and branch and wherever pipes changes direction or otherwise requires cleanouts for proper cleaning of the entire vacuum system. Cleanout can be accomplished by using tees instead of elbows or double Y or TY fittings instead of Y or TY fittings.

3. Valves and Specialties

   a. Provide unions or flanges wherever necessary and in piping at all equipment so that piping may be conveniently broken and moved to facilitate equipment maintenance.

   b. Provide isolation valves on all lines before they leave the utility corridor and at each floor level.

3.2 FIELD QUALITY CONTROL

A. General Testing Procedures:

1. All piping systems shall be tested and proven tight prior to concealment. The test shall be witnessed by the Architect/Engineer, plumbing inspector, or the Owner's representative.

2. Insure that the test pressure that might damage fixtures or equipment does not reach such units by valving them off or otherwise isolating them during the test.

END OF SECTION 226113

SECTION 230500
COMMON WORK RESULTS 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 SUMMARY

A. This Section includes:

1. Piping materials and installation instructions common to most piping systems.

~~2. Concrete equipment base construction requirements.~~

~~3.~~2. Equipment nameplate data requirements.

~~4. Nonshrink grout for equipment installations.~~

~~5. Field-fabricated metal and wood equipment supports.~~

~~6.~~3. Installation requirements common to equipment specification sections.

~~7.~~4. Mechanical demolition.

~~8.~~5. Cutting and patching.

~~9.~~6. Touch-up painting and finishing.

B. The plans and specifications are complimentary and shall be used together in order to fully describe the Work. In the case of a conflict between the plans and specifications, the plans take precedence.

C. The NREL Technical Representative has based the drawings and design on non-certified information furnished by various equipment manufacturers. It is incumbent on the part of the CONTRACTOR to include in the bid all material and labor needed to install the actual equipment furnished.

D. Related Sections:

1. The following is work of Division 26 sections of the Specifications:
    a. Power supply wiring from power source to power connection on equipment. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
    b. Interlock wiring between field-installed equipment, except where specified as factory installed. Interlock wiring, as used in this specification, is defined as that wiring between electrically-interlocked equipment for the purpose of controlling one piece or pieces of equipment by the operation (on, off, etc.) of another piece or pieces of associated equipment.
2. Pipe and pipe fitting materials as specified in piping system sections.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe 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 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.~~E. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

~~G.~~F. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 REFERENCES

A. Applicable Standards:

1. American Society for Testing and Materials (ASTM):
   a. A47 - Ferritic Malleable Iron Castings.
   b. A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   c. A126 - Gray Iron castings for Valves, Flanges, and Pipe Fittings.
   d. A536 - Ductile Iron Castings.
   e. B32 - Solder Metal.
   f. C1107 - Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
   g. D709 - Laminated Thermosetting Materials.
2. American Society of Mechanical Engineers (ASME):
   a. Boiler and Pressure Vessel Code.
   b. A13.1 - Scheme for the Identification of Piping Systems.
   c. B1.20.1 - Pipe Threads, General Purpose (Inch).
   d. B16.20 - Ring-Joint Gaskets and Grooves for Steel Pipe Flanges.
   e. B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.
   f. B18.2.1 - Square and Hex Bolts and Screws-Inch Series.
   g. B31 Series - Code for Pressure Piping.

3. American Welding Society (AWS):
   a. Soldering Manual, latest.
   b. Brazing Manual, latest.
   c. A5.8 - Filler Metals for Brazing.
   d. D1.1 - Structural Welding Code for Steel.
   e. D10.12 - Recommended Practices and Procedures for Welding Low Carbon Steel Pipe.

1.5 SUBMITTALS

A. Submit manufacturer's data sheets on all system components, including the following:
   1. Transition fittings
   2. Dielectric fittings
   ~~3. Mechanical sleeve seals~~
   ~~4.~~3. Escutcheons

B. General, all Division 23 sections of the Specifications: Follow the procedures specified in Division 1. Prepare maintenance manuals in accordance with Division 1 sections of the Specifications.

~~C. Welder certificates signed by Contractor certifying that welders comply with requirements specified under the "Quality Assurance" article of this section.~~

~~1.6 QUALITY ASSURANCE~~

~~A. Qualify welding processes and operators for structural steel according to AWS D1.1.~~

~~B. All welding on pressure piping shall conform with the requirements of the American National Standard Code for Pressure Piping, ANSI B31.3, "Chemical Plant and Petroleum Refinery Piping." All welds on piping having working pressures of 300 psig or greater shall be subjected to a full X-ray examination and will not be accepted until all welds meet the requirements of ANSI B31.1, "Power Piping." Faulty welds shall be removed at no additional cost to NREL. X-ray testing shall be performed by others at no additional cost to the Contractor.~~

~~1. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current.~~

~~C. Pressure Vessels: Prior to installation and acceptance, any power boiler, low-pressure heating boiler, or unfire pressure vessel operated at pressures of 15 pounds per square inch or greater, furnished under this contract will be stamped with ASME Boiler and Pressure Vessel Code Symbol and a National Board of Boiler and Pressure Vessel Inspector's number, thus certifying that the vessel has been fabricated and tested per the provisions of the ASME Boiler and Pressure Vessel Code. Manufacturers' data reports (unless exempted by the ASME Code) will be filed with the National Board in Columbus, Ohio. Two copies of these data reports shall be submitted to NREL. Testing, certification, and registration will be at the expense of the Contractor.~~

~~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, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.~~

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~~1.7~~1.6 DELIVERY, STORAGE, AND PROTECTION

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

E. Materials and equipment furnished by others.

1. When equipment or materials are indicated to be furnished by others (F.B.O.) or by government furnished equipment (GFE) to the CONTRACTOR for installation and connection, the CONTRACTOR shall make a complete check of all materials and furnish a receipt to the NREL detailing the products received and the condition of the products delivered to him. After executing the receipt and acceptance by the CONTRACTOR, the CONTRACTOR shall assume full responsibility for the safe keeping, handling, and installation of the materials and equipment furnished by others or furnished by government, until completed installation and final approval by the NREL Technical Representative.

2. If the CONTRACTOR fails to issue said receipt it shall be assumed that all equipment and materials were then delivered to the CONTRACTOR in the proper quantities and in perfect condition.

~~1.8~~1.7 PROJECT SITE CONDITIONS

A. Altitude Ratings: Unless otherwise noted, all specified equipment capacities, air quantities, etc., are for an altitude of 6,000 feet above sea level. Adjustments to manufacturers' ratings must be made accordingly.

~~1.9~~1.8 SEQUENCING AND SCHEDULING

A. Coordinate mechanical piping and equipment installation with other building components.

B. Arrange for chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

~~C. Coordinate the installation of required supporting devices and set sleeves in poured in place concrete and other structural components, as they are constructed.~~

~~D.~~C. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

~~E.~~D. Interruption of Mechanical Utilities:

1. The Contractor shall not interrupt any main interior or exterior mechanical utility without written request for an outage and a subsequent approval of NREL Construction Manager nor shall he interrupt any branch line to an outlet or item of equipment without approval from the NREL Construction Manager.

2. Written request for outages shall be submitted seven calendar days in advance of the outage date. This request will delineate the particular utility or service in question, the time the service will be interrupted and the approximate hours the utility shall be off.

3. Unless otherwise noted on the drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions of service shall be performed on a during non standard hours

4. The work to be performed during the interruption, will be preceded by all possible preparation, and will be carefully coordinated to minimize the duration of the interruption and work will proceed continuously until the system is restored to normal.

5. Unless otherwise directed, the manipulation of existing main valves to isolate piping, the shutdown of fans, pumps, and other equipment will be done by NREL maintenance personnel.

~~F.~~E. Coordinate installation of identifying devices after completion of covering and painting, where devices are applied to surfaces. Install identifying devices prior to installation of acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe and Pipe Fittings:

1. Refer to individual piping system specification sections for pipe and fitting materials and joining methods.

2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

B. Joining Materials:

1. See individual piping system specification sections in Division 22 for special joining materials not listed below.

~~2. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents.~~

~~a. ASME B16.21, Nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, except where thickness or specific material is indicated.~~

~~1) Full-Face Type: For flat-face, Class 125 cast-iron and cast-bronze flanges.~~

~~2) Narrow-Face Type: For raised-face, class 250 cast-iron and steel flanges.~~

~~b. ASME B16.20, For grooved, ring joint, steel flanges.~~

~~c. AWWA C110, Rubber, flat face, 1/8 inch thick, except where other thickness is indicated; and full face or ring type, except where type is indicated.~~

~~3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.~~

~~4. Plastic Pipe Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, except where other type or material is indicated.~~

~~5.~~2. Solder Filler Metal: ASTM B32.

a. Alloy Sn95 or Alloy Sn94: Tin (approximately 95%) and silver (approximately 5%), having 0.10% lead content.

b. Alloy E: Tin (approximately 95%) and copper (approximately 5%), having 0.10% maximum lead content.

c. Alloy HA: Tin-antimony-silver-copper-zinc, having 0.10% maximum lead content.

d. Alloy HB: Tin-antimony-silver-copper-nickel, having 0.10% maximum lead content.

e. Alloy Sb5: Tin (95%) and antimony (5%), having 0.20% maximum lead content.

~~6.~~3. Brazing Filler Metals: AWS A5.8.

a. BCuP Series: Copper-phosphorous alloys.

b. BAgl: Silver alloy.

~~7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.~~

~~8. Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon steel bolts and nuts.~~

~~9.~~4. Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end, pressure pipes.

a. Sleeve: ASTM A126, Class B, gray iron.

b. Followers: ASTM A47, Grade 32510 or ASTM A536 ductile iron.

c. Gaskets: Rubber.

d. Bolts and Nuts: AWWA C111.

e. Finish: Enamel paint.

C. Piping Specialties:

1. Dielectric Fittings: Assembly or fitting having insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.

a. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching 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°F temperature.

~~d. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150 or 300 psig minimum pressure to suit system pressures.~~

~~e. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.~~

~~1) Provide separate companion flanges and steel bolts and nuts for 150- or 300-psig minimum working pressure to suit system pressures.~~

~~2) Dielectric Couplings: Galvanized steel coupling, having inert and noncorrosive, thermoplastic lining, with threaded ends and 300-psig minimum working pressure at 225°F temperature.~~

~~3) Dielectric Nipples: Electroplated steel nipple, having inert and noncorrosive, thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig working pressure at 225°F temperature.~~

2. Mechanical Sleeve Seals: Modular, watertight, mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.

3. Sleeves: The following materials are for wall, floor, slab, and roof penetrations:

   a. Steel Pipe: ASTM A53, Type E, Grade A, Schedule 40, galvanized, plain ends.

   b. Wall Penetration Systems: Wall sleeve assembly, consisting of housing, gaskets, and pipe sleeve, with one mechanical joint end conforming to AWWA C110 and one plain pipe sleeve end.

      1) Penetrating Pipe Deflection: 5% without leakage.

      2) Housing: Ductile-iron casting having water stop and anchor ring, with ductile-iron gland, steel studs and nuts, and rubber gasket conforming to AWWA C111, of housing and gasket size as required to fit penetrating pipe.

      3) Pipe Sleeve: AWWA C151, ductile-iron pipe.

      4) Housing-to-Sleeve Gasket: Rubber or neoprene, push-on type, of manufacturer's design.

   ~~c. Cast-Iron Sleeve Fittings: Commercially made sleeve having integral clamping flange, with clamping ring, bolts, and nuts for membrane flashing.~~

~~D. Grout: Nonshrink, Nonmetallic Grout: ASTM C1107, Grade B.~~

~~1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.~~

~~2. Design Mix: 5000 psi, 28-day compressive strength.~~

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. Piping Systems - Common Requirements:

1. General: Install piping as described below, except where system sections specify otherwise. Individual piping system specification sections in Division 23 specify piping installation requirements unique to the piping system.

2. General Locations and Arrangements: Drawings (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, except where deviations to layout are approved on coordination drawings.

3. Install piping at indicated slope.

4. Install components having pressure rating equal to or greater than system operating pressure.

5. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.

6. Install piping free of sags and bends.

7. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.

8. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

9. Install piping to allow application of insulation plus 1-inch clearance around insulation.

10. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

11. Install fittings for changes in direction and branch connections.

12. Escutcheons: Where uncovered exposed pipes pass through floors, finished walls, or finished ceilings, they shall be fitted with chromium-plated cast-brass plates on chromium-plated pipe, or with cast-iron or steel plates on ferrous pipe. Plates shall be large enough to completely close the holes around the pipes and shall be square, octangular, or round, with the least dimension not less than 1-1/2 inches or more than 2-1/2 inches larger than the diameter of the pipe. Plates shall be secured in an approved manner.

13. Install sleeves for pipes passing through concrete and masonry walls, concrete floor and roof slabs, and where indicated.

~~14. Above Grade, Exterior Wall, and Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.~~

~~a. Install steel pipe for sleeves smaller than 6 inches.~~

~~b. Install cast-iron wall pipes for sleeves 6 inches and larger.~~

~~c. Assemble and install mechanical seals according to manufacturer's printed instructions.~~

~~15. Below Grade, Exterior Wall, and Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.~~

~~16. Below Grade, Exterior Wall, and Pipe Penetrations: Install ductile-iron wall penetration system sleeves according to manufacturer's printed installation instructions.~~

~~17.~~14. Verify final equipment locations for roughing in.

~~18.~~15. See equipment specifications in other sections of these specifications for roughing-in requirements.

~~19.~~16. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system specification sections.

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 pipe and fittings before assembly.

c. Soldered Joints: Construct joints according to AWS "Soldering Manual."

d. Brazed Joints: Construct joints according to AWS "Brazing Manual."

e. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

~~f. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of~~

~~flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.~~

~~20.~~17. Piping Connections: Except as otherwise indicated, make piping connections as specified below.

a. Install unions, in piping 2 inches and smaller, adjacent to each valve and at final connection to each piece of equipment having 2-inches or smaller threaded pipe connection.

~~b. Install flanges, in piping 2-1/2 inches and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.~~

~~c. Dry Piping Systems (Gas, Compressed Air, and Vacuum): Install dielectric unions and flanges to connect piping materials of dissimilar metals.~~

~~d.~~b. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

B. Equipment Installation - Common Requirements:

1. Install equipment to provide the maximum possible head room, where mounting heights are not indicated.
2. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the NREL.
3. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, except where otherwise indicated.
4. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
5. Install equipment giving right-of-way to piping systems installed at a required slope.
6. Shaft Alignment: All motors and pumps (or drives) connected by a shaft coupling, whether factory or field assembled, shall be aligned during installation using a dial indicator applied to both ends of both shafts for a full 360 degrees prior to operation. Alignment of the shafts shall be less than the maximum allowable tolerances as recommended by the coupling or equipment manufacturer. Alignment of shafts shall be rechecked after several hours of operation and equipment has reached operating temperature.

C. Painting and Finishing:

1. Field painting requirements are specified in Division 9 sections of the Specifications.
2. Damage and Touch-Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

D. Identification Tags and Labels:

1. Materials:

a. Pipe Labels: Pipe labels shall be self-adhesive labels, all temperature Perma-Code pipe markers No. B-500, manufactured by the W. H. Brady Company. The background color code for all markers shall conform to the American National Standard ANSI A-13.1 "Scheme for the Identification of Piping Systems." This standard establishes four basic backgrounds as follows: Yellow for dangerous

materials, bright blue for protective materials, red for fire protection equipment, and green for safe materials.

b. Tags: Tags shall be aluminum, brass or laminated plastic 2" x 1" minimum with edges ground smooth or rolled. Each tag shall be punched to receive tie wires or chain. Letters and Numbers shall be evenly spaced and stamped or engraved into the surface.

2. Installation:

a. Identification of Piping:

1) Identify all piping according to the following procedures:

a) Bare pipes to be marked shall first be wiped clean of dirt, dust, grease, and moisture. Markers to be installed on painted piping shall be applied only after completion of final coat of paint. Insulated pipes shall first be painted to a smooth, hard surface in the area the label is to be applied. Labels shall be applied, using pressure, so that it lies smooth and flat. After application on insulated pipes, the label shall be stapled securely to the insulation. The labels shall be applied to the pipe so that the lettering is in the most legible position. For overhead piping apply markers on the lower half of the pipe where view is unobstructed, so that markers can be read at a glance from floor level. The wording on the labels shall correspond directly to the wording in the mechanical symbol lists, regardless of whether or not it is standard wording for the designated manufacturer.

b) Use an arrow marker with each pipe content marker. The arrow shall always point away from the pipe marker and in the direction of flow, with background color and height the same as content marker. If flow can be in both directions, use two arrow markers.

c) Apply pipe marker and arrow marker at each valve, at every point of pipe entry or exit through wall or ceiling, on each riser and branch of tee, and every 20 feet on long continuous lines or at every bay or aisle to show proper identification of pipe content and direction of flow.

b. Valves: All main service valves, including fire protection, located inside the building shall be tagged and identified as to the type of service. All valves controlling branch mains or risers to various portions of the building shall be tagged and identified as to the areas served.

c. Controls: All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the contract drawings.

~~d. Pumps: All pumps shall be identified as to service with aluminum or brass tags secured by tie wires.~~

~~E. Concrete Bases: Construct concrete equipment bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 psi, 28-day compressive strength concrete and reinforcement as specified in Division 3 sections of the Specifications. Housekeeping pads under pumps, etc. shall be 3-1/2 inches thick with #4 reinforcing bars 12 inches on center each way unless otherwise noted.~~

~~F.~~E. Erection of Metal Supports and Anchorage:

1. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
2. Field Welding: Comply with AWS D1.1 "Structural Welding Code - Steel."

~~G.~~F. Cutting and Patching:

1. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.
2. Repair cut surfaces to match adjacent surfaces.

~~H. Grouting:~~

~~1. Install nonmetallic, nonshrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates and anchors. Mix grout according to manufacturer's printed instructions.~~

~~2. Clean surfaces that will come into contact with grout.~~

~~3. Provide forms for placement of grout, as required.~~

~~4. Avoid air entrapment when placing grout.~~

~~5. Place grout, completely filling equipment bases.~~

~~6. Place grout on concrete bases to provide a smooth bearing surface for equipment.~~

~~7. Place grout around anchors.~~

~~8. Cure placed grout according to manufacturer's printed instructions.~~

END OF SECTION 230500

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SECTION 230519
METERS AND GAUGES FOR HVAC PIPING

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 SUMMARY

A. This Section includes:

1. Temperature Gauges and Fittings
2. Pressure Gauges and Fittings
3. ~~Flow Meters~~

1.3 REFERENCES

A. Applicable Standards:

1. American National Standards Institute (ANSI):
   a. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
   b. B16.24 - Bronze Pipe Flanges and Flanged Fittings, Class 150 and 300
2. American Society of Mechanical Engineers (ASME): B40.1 Gauges - Pressure, Indicating Dial Type - Elastic Element
3. Instrument Society of America (ISA)
4. Underwriters Laboratories (UL)

1.4 SUBMITTALS

A. See Division 23 sections of the Specifications.

1. Product data for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.
2. Maintenance data for each type of meter and gauge, for inclusion in Operating and Maintenance Manuals specified in Division 1 sections of the Specifications.

1.5 QUALITY ASSURANCE

A. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.

1.6 WARRANTY

A. See the procedures in Division 23 sections of the Specifications.

PART 2 - GENERAL

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products from one of the following:

1. Mercury-In-Glass Thermometers: NOT USED.

2. Digital pipe insertion Thermometers: Weiss Instruments, Inc.

3. Thermometer Wells: Same as for thermometers.

~~4. Bi-metal Thermometers: Submit for approval.~~

~~5.~~4. Pressure Gauges:

a. Ametek; U.S. Gauge Div.

b. Ashcroft Dresser Industries/Instrument Div.

c. Marsh Instrument Co.; Unit of General Signal

d. Marshalltown Instruments, Inc.

e. Weiss Instruments, Inc.

f. Weksler Instruments Corp.

g. WIKA Instruments Corp.

~~6.~~5. Pressure Gauge Accessories: Same as for pressure gauges.

~~7. Insertion Type Flow Meters: Onicon Turbine Flow Measurement System~~

2.2 MANUFACTURED UNITS

A. Thermometers:

1. Thermometers, General:

a. Accuracy: ±1% of range span or ±1 scale division to maximum of 1.5% of range span.

b. Scale range: Temperature ranges for services are as listed below.

1) Hydronic systems -40°F to 300°F in 0.1° divisions (digital readout)

2) Flue Gas: 50° to 500°F in 5° scale divisions.

3) Air Systems: -40°F to 300°F in 0.1° divisions (digital readout)

2. Mercury-In-Glass Thermometers: NOT USED.

~~3. Bi-metal Thermometers:~~

~~a. Case: Stainless steel case, bezel, fittings, and stem.~~

~~b. Scale: White scale plate with black figures and anti-parallax glass.~~

~~4.~~3. Thermometer Wells: Type: Brass or stainless steel, pressure rated to match piping system design pressure, with 2-inch extension for insulated piping, and threaded cap nut.

B. Pressure Gauges:

1. Pressure Gauges, General:

a. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection.

b. Case: Drawn steel or brass, glass lens, 4-1/2-inch diameter.

c. Connector: Brass, 1/4-inch NPS.

d. Scale: White coated aluminum with permanently etched markings.

e. Accuracy: ±1% of range span.

f. Range: Conform to the following:

1) Vacuum: 30 inches Hg to 15 psi.

2) All fluids: Two times operating pressure.

2. Pressure Gauge Accessories:

a. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

b. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

c. Gauge isolation valves: All gauges shall have a service valve consisting of a 1/4-inch NPT threaded ball valve with at least a 3-inch-long operating handle. Petcocks are prohibited.

~~3. Flow Meters, General: Flow rate of elements and meters shall be same as connected equipment or system.~~

~~4. Insertion Type Flow Meters:~~

~~a. Single Turbine Insertion Flow Element. Turbine type, designed for installation in piping. Paddle wheel type sensors are not acceptable.~~

~~b. Construction: The turbine element shall be constructed of polypropylene or polysulfone with sapphire jewel bearings and tungsten carbide shafts. The flow sensor shall be constructed of 316 stainless steel with an aluminum electronics enclosure and a gasketed cover. Flow sensor shall have a 50:1 turndown ratio. Accuracy shall be ±2% of actual flow reading from 0.4 feet per second to 20.0 feet per second. The sensor shall have an output signal that can be directly connected to the NREL Delta® DDC system without intermediate electronic devices. The flow sensor shall not use magnetic or photoelectric means to detect flow.~~

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. Installation of Thermometers:

1. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

2. Install as shown on plans.

3. Thermometer Wells: Install in piping where thermometers are indicated in vertical position. Fill well with temperature conduction grease, oil, or graphite and secure cap.

B. Installation of Pressure Gauges:

1. Mechanical Spaces: Install pressure gauges in piping with pressure gauge located at most readable position. Extend fittings as needed to make gauge readable to plant operators. Gauges not readable by an observer standing on floor are unacceptable and will be relocated at the contractor's expense.

2. Finished Spaces: Pressure gauges installed above dropped ceilings will face down or be located at the most readable position for service personnel.

3. Extend gauge piping to allow for insulation. Gauge shutoff valves must be operable after insulation is installed. Install in the following locations and elsewhere as indicated:

   a. Across suction and discharge of each pump.

   b. Differential pressure (DP) gauge assemblies: DP gauges assemblies will be installed across the suction and discharge of pumps. The DP gauge shall have 1/4-inch ball valves on the pump suction and discharge connections. Connecting fittings shall be 1/4 inch NPT. (Valves and fittings may match port size on pumps with factory equipped gauge port taps.) A snubber shall be installed on the gauge to reduce gauge needle oscillations.

C. Installation of Flow Measuring Elements and Meters:

1. General: Install gauges and thermometers in piping systems located in accessible locations at most readable position.

2. Locations: Install flow measuring elements and meters where indicated. Single turbine flow meters require 40 pipe diameters of straight pipe ahead of the flow element. Consult the manufacturer's recommendations for installing dual turbine flow meters.

3.2 ADJUSTING

A. Adjust faces of meters and gauges to proper angle for best visibility.

3.3 CLEANING

A. Clean windows of meters, gauges and factory finished surfaces. Replace cracked or broken windows; repair scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 230519

SECTION 230523
GENERAL-DUTY VALVES FOR HVAC PIPING

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 SUMMARY

A. This Section includes valves for ~~chilled water, condenser water and~~ heating hot water piping for HVAC systems.

1.3 REFERENCES

A. American Petroleum Institute (API)

1. Standard 600 - Steel Gate Valve - Flanged and Butt-Welding Ends, Bolted and Pressure Sealed Bonnets.
2. Standard 607 - Fire Test for Soft-Seated Quarter-Turn Valves.

B. American Society of Mechanical Engineers (ASME)

1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.
2. B16.5 - Pipe Flanges and Flanged Fittings.
3. B16.10 - Face-to-Face and End-to-End Dimensions of Valves.
4. B16.11 - Forged Steel Fittings, Socket-Welding and Threaded.
5. B16.34 - Valves - Flanged, Threaded and Welding End.
6. B31.1 - Power Piping.
7. B31.9 - Building Services Piping Code.

C. American Society for Testing and Materials (ASTM)

1. A105 - Specification for Forgings, Carbon Steel, for Piping Components.
2. A216 - Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
3. A351 - Specification for Castings, Austenitic, Austenitic-Ferric (Duplex) for Pressure Containing Parts.
4. B584 - Specification for Copper Alloy Sand Castings for General Applications.
5. D1784 - Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

D. American Water Works Association (AWWA)

1. C508 - Swing Check Valves for Waterworks Service, 2-inch through 24-inch NPS.

E. Fluid Control Institute (FCI)

1. 70-2 - Quality Control Standard for Control Valve Seat Leakage.

F. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)

1. SP-61 – Pressure Testing of Steel Valves.

1.4 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. NBR: Acrylonitrile-butadiene rubber.
4. PTFE: Polytetrafluoroethylene plastic.
5. TFE: Tetrafluoroethylene plastic.

1.5 SUBMITTALS

A. See Division 23sections of the Specifications.

B. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.6 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves.

1. Exceptions: Domestic hot- and cold-water piping valves unless referenced.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

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 handwheels or stems as lifting or rigging points.

1.8 WARRANTY

A. Follow procedures specified in Division 1.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide valves of manufacturers listed below and of the figure numbers listed, or as updated by the manufacturer. Submittals containing outdated figure numbers will be rejected. Manufacturers and numbers not listed are unacceptable.

B. Provide butterfly and plug valves NPS 4 and larger with worm gear operators with position indicators.

C. Provide butterfly, ball and plug valves of bubble-tight and dead end construction.

D. Valve packing containing asbestos material will not be permitted.

E. Equip bronze globe and gate valves with a hexagon gland follower.

F. Equip bronze globe and gate valves with malleable iron hand wheels.

G. Provide manually operated valves, pad-lockable in any position.

H. Provide gate and globe valves which are capable of being packed under pressure when wide open by means of a beveled backseat and bonnet.

I. Provide all gate and globe valves with four-sided stem to hand-wheel connection with self-locking nut.

2.2 HEATING HOT WATER, ~~CONDENSER WATER, GLYCOL, CHILLED WATER,~~ UNLESS OTHERWISE SHOWN OR SPECIFIED

A. Isolation and Throttling Valves – NPS 2 and Smaller

~~1. Class 150 psi swp, 600 psi cwp; three piece; full port; bronze body; blow-out proof stem; chromium plated brass or bronze ball; TFE seats and packing; adjustable packing gland; in-line repairable; threaded ends; lever handle with lockable feature; stem extensions for insulated services.~~

~~Conbraco/Apollo~~	~~82-100~~
~~Crane~~	~~F-9303~~
~~Grinnell~~	~~3810~~
~~Hammond~~	~~8604~~
~~Milwaukee~~	~~BA-300~~
~~NIBCO~~	~~T-595-Y~~
~~Watts~~	~~B-6800~~

~~2.~~1. Class 150 psi swp; 600 psi cwp; two-piece, regular port; bronze body; blow-out proof stem; chromium plated brass or bronze ball; TFE seats and packing; adjustable packing gland; threaded ends; oval handle with lockable feature; stem extensions for insulated service.

Conbraco/Apollo	70-100
Crane	9302
Grinnell	3700
Hammond	8501
Milwaukee	BA-100
Jamesbury	14-00-TT
NIBCO	T-585-70
Watts	B-6000

B. Drain and Vent Valves

1. Class 150 psi swp, 600 psi cwp; two piece; large port; blow-out proof stem; chromium plated brass ball; TFE seats and packing; adjustable packing gland; oval handle with lockable feature; hose-end threaded connection with brass cap and chain connected to handle.

Conbraco/Apollo	78-100
NIBCO	T-580-70-HC
Hammond	8501H
Watts	B-6000-CC

~~C. Isolation and Throttling Valves – NPS 2-1/2 and Larger~~

~~1. Butterfly; rated 200 psi up to NPS 12 and 150 psi NPS 14 and larger; full lug type; suitable for dead-end service to full shut-off differential of valve with downstream flange removed; cast/ductile iron body; aluminum bronze disc; stainless steel stem; EPDM seat; manual lever-lock operator; minimum 2-inch extended neck for insulation; phenolic backed liner. Seat material for oil or hydrocarbon service: BUNA in lieu of EPDM. Provide gear operators with pad lock feature on all valves NPS 4 and larger.~~

~~Conbraco/Apollo~~	~~142~~
~~ABZ~~	~~102~~
~~Bray~~	~~Series 31-11010-120~~
~~DeZURIK~~	~~BGS-LI-CI-EPDM-BZS5-LT~~
~~Grinnell~~	~~LC/LD-2281-3~~
~~Hammond~~	~~6211-01~~
~~TYCO/Keystone~~	~~AR2~~
~~Muesco~~	~~56-A-H-K-6-2~~
~~NIBCO~~	~~LC/LD-2000-3/-1000-3~~
~~Stockham~~	~~LG-712-BS2-E~~
~~Victaulic~~	~~300,709~~
~~Watts~~	~~DBF-03-121-1P~~

~~D.~~C. Check Valves – NPS 2 and Smaller

1. Class 200 psi swp, 400 psi cwp; bronze body, disc and seat; regrinding; screwed end.

Crane	36
Hammond	IB944
Lunkenheimer	544Y
Milwaukee	508
NIBCO	T-453-B
Powell	560
Stockham	B-345
Walworth	3420
Watts	B-5020

~~E. Check Valves – NPS 2-1/2 (DN 65) and Larger~~

~~1. Silent type, globe style, integrally flanged, class 150, cast iron body, resilient seated, stainless steel trim and spring.~~

~~Apco~~	~~Series 600~~
~~Muesco~~	~~105M-AT~~
~~Metraflex~~	~~# 900 Series~~
~~Grinnell~~	~~Series 500~~

~~Victaulic~~	~~716,779~~
~~NIBCO~~	~~F910/960~~

2.3 PRESSURE INDEPENDANT CONTROL VALVES WITH ACTUATOR (PICV)

A. Provide pressure control valves on closed circulating systems for regulation of head pressure: Similar to Danfoss Model: AB-QM or Flow Control Industries Model: DeltaPValve, modulating type, max pressure rating: 300 psi. size valves for piping system where installed and adjust to system pressures.

~~**2.4 SOLENOID VALVES**~~

~~A. 2-way, pilot operated, slow closing type.~~

~~B. Solenoid enclosure: General purpose metal type.~~

~~C. Voltage: 24 volts, ac, 60 Hz 24 volts dc.~~

~~D. Coil: Continuous duty molded Class F.~~

~~E. Ambient temperature range: 32 degrees F to 125 degrees F.~~

~~F. Body: 18.8 S.S.~~

~~G. Seals and Disc: Buna "N".~~

~~H. Core tube: 305 S.S.~~

~~I. Core and plug nut: 430F S.S.~~

~~J. Core spring: 302 S.S.~~

~~K. Shading coil: silver (stainless steel body).~~

~~L. Manufacturers: ASCO "Red Hat Series 8221" or Honeywell "Skinner Model 7321 GBN".~~

~~**2.5 DIAPHRAGM VALVES**~~

~~A. Provide straightway flow diaphragm valves on closed circulating systems where required for flow regulation and isolation: Dia-Flo Straightway Valves as manufactured by ITT Industries, motor operated modulating type where indicated on the drawings.~~

~~B. Size valves for piping system where installed and adjust to control pressures shown. Select valve and diaphragm materials to operate at the piping system pressure ratings and the temperature range of the liquid in the piping system. In general valves for chilled water and heating water service shall be cast iron body with butyl rubber lining rated to minimum 125 psig and 200 deg. F.~~

PART 3 - EXECUTION

3.1 VALVE 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 and examine guides and seats made accessible.

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 the proper size, that its material composition is suitable for the service, and that it is free from defects and damage.~~

~~E.~~D. Do not attempt to repair defective valves; replace with new valves.

3.2 JOINT CONSTRUCTION

A. See Division 23 sections of the Specifications for basic piping joint construction.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 VALVE INSTALLATION

A. General

1. Provide isolation valves in piping services where branch lines connect to mains and risers.
2. Provide isolation valves where service is fully open or closed.
3. Provide throttling valves where pressure regulation or modulating flow are required.
4. Provide throttling valves to serve as drain valves at low points and at piping dead ends.
5. Provide only ball valves on strainer blow down service.
6. Provide plugs or caps on all drain, vent or other open ended lines and valves.
7. Provide NPS ¾ drain valves on piping up through NPS 4 and NPS 1-1/2 drain valves on piping NPS 5 and larger.
8. ~~Provide valves NPS 2-1/2 and larger with a drain valve on upper side of valve.~~

B. Isolation Valves and Unions at Equipment

1. Provide isolation valves and unions at the individual connections to equipment, PRV stations and piping elements to permit complete servicing or removal of piping elements and items of equipment.

C. By-Pass Valves

1. Where by-pass valves are shown to be installed around pressure regulating valves and automatic control valves, size the by-pass valve the same size as the pressure regulating or automatic control valve.

D. Automatic Valves

1. Install automatic valves furnished as specified in Division 23 sections of the Specifications.

E. Copper Tubing Adapters

1. When connecting copper tubing to valves, install adapters as follows:
   a. Cast copper solder male adapter or union to screwed valves.
   b. Copper solder joint companion flange unit.
2. Solder joint valve substitutions for valves specified are not permitted.

END OF SECTION 230523

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes extent of supports and anchors required by this Section is indicated on drawings and/or specified in other Division 23 sections of the Specifications.

1.3 REFERENCES

A. Applicable Standards:

1. American Society of Mechanical Engineers (ASME): B31.9 - Building Services Piping.
2. American Society for Testing and Materials (ASTM):
   a. A36 - Structural Steel.
   b. A780 - Repair of Damaged Hot-Dipped Galvanized Coatings.
   c. C150 - Portland Cement.
   d. C404 - Aggregates for Masonry Grout.
3. American Welding Society (AWS). D1.1 - Structural Welding Code - Steel.
4. Factory Mutual (FM).
5. National Electrical Manufacturers' Association (NEMA).
6. Underwriters Laboratories (UL).

1.4 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology used in this Section is defined in MSS SP-90.

1.5 SUBMITTALS

A. General: Submit the following in accordance with Division 23 related sections of the Specifications.

1. Product data including installation instructions for each type of support and anchor.
2. Maintenance data for supports and anchors for inclusion in Operating and Maintenance Manual specified in Division 23 sections of the Specifications.

1.6 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS_D1.1.

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Qualify welding processes and welding operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications."

C. Regulatory Requirements: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide hangers and supports from one of the following:

1. B-Line System Inc.
2. Carpenter and Patterson, Inc.
3. Corner & Lada Co., Inc.
4. Elcen Metal Products Co.
5. Unistrut
6. ITT Grinnel Corp.

2.2 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A36.

~~B. Cement Grout: Portland cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix ratio shall be 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.~~

~~C.~~B. Pipe Alignment Guides: Factory fabricated, of cast steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

2.3 MANUFACTURED UNITS

A. Hangers and support components shall be factory fabricated. Baling wire is prohibited for permanent support.

1. Components shall have galvanized coatings where installed for piping and equipment that will not have field-applied finish.
2. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.
3. Thermal Hanger Shield Inserts: 100 psi average compressive strength, waterproofed calcium silicate, and encased with a sheet metal shield. Insert and shield shall cover entire circumference of the pipe and shall be of length indicated by manufacturer for pipe size and thickness of insulation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions under which supports and anchors are to be installed. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 ERECTION INSTALLATION APPLICATION

A. Examine substrates and conditions under which supports and anchors are to be installed. Do not proceed with installation until unsatisfactory conditions have been corrected.

1. General: Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible. Install supports

with maximum spacing complying with MSS SP-69. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.

2. Attaching supports to bar joists: Pipe hangers for pipe 2 1/2" and over in diameter. Where pipe hangers and supports are to be attached to bar joists, the attachment is to be made from the top chord of the bar joists. Attachments to the bottom chord are unacceptable.

3. Install building attachments ~~within concrete or~~ to structural steel. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. ~~Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.~~

4. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

5. Install hangers and supports to allow controlled movement of piping system to permit freedom of movement between pipe anchors and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

6. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

7. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ASME B31.9 is not exceeded.

8. Insulated Piping: Comply with the following installation requirements:

   a. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.

   b. Saddles: Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.

   c. Shields: Install protective shields MSS Type 40 on chilled water piping that has vapor barrier. Shields shall span an arc of 180o and shall have dimensions in inches not less than the following:

NPS	LENGTH	THICKNESS
¼ THROUGH 3-1/2	12	0.048
~~4~~	~~12~~	~~0.060~~
~~5 & 6~~	~~18~~	~~0.060~~
~~8 THROUGH 14~~	~~24~~	~~0.075~~
~~16 THROUGH 24~~	~~24~~	~~0.105~~

~~d. Pipes 8 inches and larger shall have wood inserts.~~

~~e.~~d. Insert material shall be at least as long as the protective shield.

~~f.~~e. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

~~g.~~f. Hangers supporting bare copper pipe shall be copper plated. Field paint all clamps, saddles, and shields.

B. Installation of Anchors - Attaching Supports to Bar Joists: Pipe hangers for pipe 2 1/2" and over in diameter. Where pipe hangers and supports are to be attached to bar joists, the attachment is to be made from the top chord of the bar joists. Attachments to the bottom chord are unacceptable.

1. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install anchor by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS D1.1.
3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions to control movement to compensators.
4. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe-runs and at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

C. Installation of Pipe Alignment Guides: Install pipe alignment guides on piping that adjoins expansion joints and elsewhere as indicated. Anchor to building structure.

D. Install hangers for horizontal piping with following maximum spacing and minimum rod sizes:

Nom. Pipe	Steel Pipe	Copper Tube	Min. Rod
Up to 3/4"	7 ft.	5 ft.	3/8"
1"	7 ft.	6 ft.	3/8"
~~1-1/4"~~	~~7 ft.~~	~~7 ft.~~	~~3/8"~~
~~1-1/2"~~	~~9 ft.~~	~~8 ft.~~	~~3/8"~~
~~2"~~	~~10 ft.~~	~~8 ft.~~	~~3/8"~~
~~2-1/2"~~	~~11 ft.~~	~~9 ft.~~	~~1/2"~~
~~3"~~	~~12 ft.~~	~~10 ft.~~	~~1/2"~~
~~3-1/2~~	~~13 ft.~~	~~11 ft.~~	~~1/2"~~
~~4"~~	~~14 ft.~~	~~12 ft.~~	~~5/8"steel, 1/2" for copper~~
~~5"~~	~~16 ft.~~	~~13 ft.~~	~~5/8" steel, 1/2" for copper~~
~~6"~~	~~17 ft.~~	~~14 ft.~~	~~3/4" steel, 5/8" for copper~~

E. Install anchor points per drawings to control pipe movement from thermal expansion.

~~F. Equipment Supports:~~

~~1. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.~~

~~2. Grouting: Place non-shrink grout under supports for piping and equipment.~~

~~G.~~F. Metal Fabrication:

1. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

~~2. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.~~

~~3. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following items:~~

~~a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.~~

~~b. Obtain fusion without undercut or overlap.~~

~~c. Remove welding flux immediately.~~

~~d. Finish welds at exposed connections so that no roughness shows after finishing and so that contours of welded surfaces match adjacent contours.~~

3.3 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

C. Touch-Up Painting: Cleaning and touch-up painting of field welds, bolted connections, and abraded areas of the shop paint on miscellaneous metal are specified in Division 23 sections of the Specifications. For galvanized surfaces, clean welds, bolted connections, and abraded areas, and apply cold galvanizing compound to comply with ASTM A780.

END OF SECTION 220529

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SECTION 230548
VIBRATION CONTROLS FOR HVAC 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes extent of vibration control work required by this Section is indicated on drawings and schedules, and/or specified in other Division 23 sections of the Specifications.

B. Types of vibration control products specified in this Section include the following:

~~1. Neoprene Pads.~~

~~2. Vibration Isolation Springs.~~

~~3. Pad-Type Isolators.~~

~~4. Neoprene Mountings.~~

~~5. Spring Isolators, Freestanding.~~

~~6. Roof Curb Isolators.~~

~~7.~~1. Isolation Hangers.

~~8.~~2. Flexible Pipe Connectors.

1.3 REFERENCES

A. Applicable Standards:

1. American National Standards Institute (ANSI).
2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

1.4 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.

1.5 SUBMITTALS

A. General: Submit the following in accordance with requirements elsewhere in Division 22 sections of the Specifications.

1. Product Data: Submit manufacturer's technical product data and installation instructions for each type of vibration control product. Submit schedule showing size, type, deflection, and location for each product furnished.
2. Maintenance Data: Submit maintenance data for each type of vibration control product. Include this data, product data, and shop drawings in maintenance manual, in accordance with requirements of Division 1 sections of the Specifications.

1.6 QUALITY ASSURANCE

~~1.6~~

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A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products, or type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than five years.

1. Except as otherwise indicated, obtain vibration control products from single manufacturer.
2. Engage manufacturer to provide technical supervision or installation of vibration control products.

PART 2 - GENERAL

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide vibration control products of one of the following:

1. Amber/Booth Co.
2. Korfund Dynamics Corp.
3. Mason Industries, Inc.
4. Peabody Noise Control, Inc.
5. Vibration Eliminator Co., Inc.
6. Vibration Mountings and Controls, Inc.

2.2 MATERIALS

~~A. Neoprene Pads: Oil-resistant neoprene sheets, of manufacturer's standard hardness and cross-ribbed or waffled pattern.~~

~~B. Vibration Isolation Springs: Wound steel compression springs, of high-strength spring alloy steel, with spring diameter not less than 0.8 of compressed height of spring at rated loads. Provide minimum additional travel to solid, equal to 50% of rated deflection. Provide spring wire with elastic limit stress exceeding stress at solid deflection.~~

~~C. Pad-Type Isolators: Except as otherwise indicated, provide manufacturer's standard pad-type isolation unit, fiberglass pads or shapes, or neoprene pads.~~

~~D. Neoprene Mountings: Provide neoprene mountings consisting of neoprene element bonded between two steel plates that are neoprene-covered to prevent corrosion. Provide minimum rated deflection of 0.35 inch. Provide threaded hole in upper plate and two holes in base plate for securing to equipment and to substrate.~~

~~E. Spring Isolators, Freestanding: Except as otherwise indicated, provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with locknuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.~~

~~1. Include holes in bottom plate for bolting unit to substrate as indicated.~~

~~F. Roof-Curb Isolators: Fabricated frame units sized to match roof curbs as shown, formed with isolation springs between extruded aluminum upper and lower sections, which are shaped and positioned to prevent metal-to-metal contact. Provide continuous airtight and waterproof seal between upper and lower extrusions. Include provisions for anchorage of frame unit to roof curb, and for anchorage of equipment unit.~~

~~G.~~A. Isolation Hangers: Hanger units formed with brackets and including manufacturer's standard compression isolators of type indicated. Design brackets for three times rated loading of units. Fabricate units to accept misalignment of 15 degrees off center in any direction before contacting hanger box, and for use with either rod or strap type members, and including acoustical washers to prevent metal-to-metal contacts.

1. Provide vibration isolation spring with cap in lower part of hanger and rubber hanger element in top, securely retained in unit.
2. Provide neoprene element, with minimum deflection of 0.35-inch, securely retained in hanger box.
3. Provide fiberglass pad or shape, securely retained in unit, with threaded metal top plate.
4. Provide hangers, precompressed to rated load to limit deflection during installation. Design so hanger may be released after full load is applied.

~~H.~~B. Flexible Pipe Connectors:

1. For nonferrous piping, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.
2. For ferrous piping, provide stainless steel hose covered with stainless steel wire braid with NPT steel nipples or 150 psi ANSI flanges, welded to hose.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION

A. General: Except as otherwise indicated, select vibration control products in accordance with ASHRAE Handbook, 2007 HVAC Applications Volume, Chapter 47 "Sound and Vibration Control," Table 48. Where more than one type of product is offered, selection is Installer's option.

B. Piping: For piping connected to equipment mounted on vibration control products, install isolation hangers as indicated, and for first 3 points of support for pipe sizes 4 inches and less~~, for first 4 points of support for pipe sizes 5 inches through 8 inches, and for first 6 points of support for pipe sizes 10 inches and over~~.

3.3 ERECTION INSTALLATION APPLICATION

A. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

~~B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.~~

~~C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.~~

~~D.~~B. Locate isolation hangers as near overhead support structure as possible.

~~E. Weld riser isolator units in place as required to prevent displacement from loading and operations.~~

~~F.~~C. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.

3.4 ADJUSTING

A. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated.

3.5 CLEANING

A. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.6 DEMONSTRATION

A. General: Comply with minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units as indicated.

B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units.

END OF SECTION 220548

SECTION 230553
IDENTIFICATION FOR HVAC 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the provision of all labor, materials and equipment required to furnish and install identification for piping, ductwork equipment and ceilings in accordance with the Contract Documents.

1.3 REFERENCES

A. American National Standards Institutes, Inc. (ANSI).

1. A13.1 - Scheme for Identification of Piping Systems

1.4 SUBMITTALS

A. See Division 1 sections of the Specifications.

B. Samples: For color, letter style, and graphic representation required for each identification material and device, including:

1. Colors for proposed pipe marker letters and fields.
2. Ceiling markers.
3. Ductwork markers.
4. Equipment markers.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1 for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.6 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 location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.7 WARRANTY

A. Refer to requirements in Division 23 sections of the Specifications.

PART 2 - PRODUCTS

2.1 PIPING MARKERS

A. Provide pipe markers consisting of pipe contents identification name with flow direction arrows.

B. Pipe Markers:

1. For piping with outside diameters (including insulation) from NPS ¾ to NPS 5, provide snap on, vinyl pipe markers consisting of coiled plastic sheets with sealed color graphics: Brady Worldwide, Inc. B-915 (Style A through E) or approved product of Seton Identification Products or MSI Marking Services, Inc.

~~2. For piping with outside diameters (including insulation) NPS 6 and larger, provide strap on, vinyl pipe markers consisting of plastic sheets with sealed color graphics, and pre-cut slots and pre-cut straps: Brady Worldwide, Inc. B-915 (Style F through H) or approved product of Seton Identification Products or MSI Marking Services, Inc.~~

2.2 VALVE TAGS

A. Provide piping NPS 1 1/2, pre-stamped, black filled, brass valve tags. Provide the top line of each tag with 1/4-inch-high letters indicating the service designation (CHW, DCW, etc.). Provide the bottom line with 7/16-inch-high numbers.

B. Brady Worldwide, Inc. 23210 or approved Product of Seton Identification Products or Marking Services, Inc.

C. Provide duplicate valve identification charts mounted in a clear anodized aluminum frame with a clear plastic lens.

D. Include the following information on the identification charts:

1. Job and Installer Name and Date
2. System
3. Valve number
4. Location
5. Purpose

2.3 CEILING MARKERS

A. Provide ceiling markers consisting of color coded dots equal to Brady Worldwide, Inc. “Series 23250” or approved product of Seton Identification Products or Marking Services, Inc.

2.4 DUCTWORK IDENTIFICATION

A. Printed label bearing the name of the:

1. Service.
2. System designation.
3. Direction of flow.

B. Letter size: 3-1/2 inches.

C. Letter type: Gothic bold style.

D. Lettering designations and color scheme:

1. Supply air: White letters on blue background.
2. Return air: Black letters on green background.
3. Relief air: Black letters on green background.
4. Exhaust: Black letters on yellow background.

E. Minimum length of label: 24 inches.

F. Self sticking indoor/outdoor vinyl markers: Brady Worldwide, Inc. “B-946” or approved product of Seton Identification Products or Marking Services, Inc.

2.5 EQUIPMENT IDENTIFICATION

A. Identify all equipment installed under this Division with 2-inch-high Gothic vinyl film black letters or numbers with permanent adhesive and conforming to the equipment designation identification shown on the Drawings: Brady Worldwide, Inc. “B-933” or approved product of Seton Identification Products or Marking Services, Inc.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE MARKERS

A. Identify the content and directional flow of all piping on the Project with the specified pipe markers.

B. Provide pipe marking that complies with ANSI A13.1 with respect to:

1. Letter color.
2. Letter size.
3. Background color.
4. Marker size (length).

C. Install pipe markers at the following pipe locations:

1. Adjacent to each valve.
2. At each change in direction.
3. At each branch connection.
4. Where pipe penetrates walls, ceilings, and floors.
5. Every 7.6 meters (25 feet) on horizontal and vertical pipe runs.

D. Apply markers after insulating and/or painting have been completed.

E. Where a service is indicated on the Drawings as a circulating system, provide the pipe marker legend for the particular service with the word "supply" or "return" as required to clarify the line function.

~~F. On steam and gravity condensate return, indicate the pressure. On pumped condensate return, indicate "pumped".~~

3.2 INSTALLATION OF VALVE TAGS

A. Attach tags to all valves using a #16 brass jack chain.

3.3 INSTALLATION OF VALVE IDENTIFICATION CHARTS

A. Mount the two valve identification charts at locations to be designated.

3.4 INSTALLATION OF CEILING MARKERS

A. Where valves, traps, dampers, control boxes, and other such devices occur above accessible suspended ceilings, provide 7/8-inch-diameter, color coded, ceiling, dot type marks in the ceiling tile where devices occur above.

3.5 APPLICATION OF DUCT LABELS

A. Label ductwork as indicated above. Label ductwork in exposed areas including mechanical rooms and in accessible shafts and chases.

B. Label straight runs a maximum of 50 feet on center; label branch ductwork within 3 feet of mains; label at each change in direction; label within 3 feet of each wall, floor, roof or ceiling penetration.

3.6 APPLICATION OF EQUIPMENT LABELS

A. Apply equipment labels on a prominent surface of the equipment where they can be readily seen from the operating floor.

3.7 PIPE IDENTIFICATION SCHEDULE

A. Provide pipe identification markers in accordance with the following schedule:

Service	Background Color	Color of Letters
Water:		
~~Condenser water~~	~~Green~~	~~White~~
Heating hot water	Yellow	Black
~~Chilled water~~	~~Green~~	~~White~~

END OF SECTION 230553

SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC SYSTEMS

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 SUMMARY

A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:

1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total HVAC systems to provide indicated quantities.
3. Measuring electrical performance of HVAC equipment.
4. Setting quantitative performance of HVAC equipment.
5. Verifying that automatic control devices are functioning properly.
~~6. Measuring sound and vibration.~~
~~7.~~6. Reporting results of the activities and procedures specified in this Section.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.

C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

E. Report Forms: Test data sheets for recording test data in logical order.

F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

K. Test: A procedure to determine quantitative performance of a system or equipment.

~~K.~~

L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.

M. AABC: Associated Air Balance Council

N. AMCA: Air Movement and Control Association.

O. CTI: Cooling Tower Institute.

P. NEBB: National Environmental Balancing Bureau.

Q. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

R. TAB: Testing, Adjusting, and Balancing

1.4 REFERENCES

A. Air Movement and Control Association (AMCA):

1. 201 – Fans and Systems

B. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. HVAC Systems – Duct Design
2. HVAC Systems – Testing, Adjusting, and Balancing

1.5 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Adjusting and balancing shall be performed in accordance with the latest edition of the National Environmental Balancing Bureau (NEBB) Procedural Standards, and in accordance with the scope of Work specified in the Contract Documents.
2. Adjusting and balancing shall not begin until systems are complete, temporary filters and strainers are removed and permanent filters installed, piping systems are cleaned, flushed and chemically treated, all as properly scheduled and approved in advance by the Architect.
3. In addition to demonstrating that the systems are capable of achieving design load point flows, the adjusting and balancing agency shall demonstrate, and so include in the report forms, that the automatic control systems respond properly to load variations.
4. Upon the completion of the Work, the adjusting and balancing agency shall submit four copies of the complete adjusting and balancing report.
5. One agency shall be responsible for all phases of adjusting and balancing.
6. The adjusting and balancing agency shall permanently mark the settings of all valves, dampers and other adjusting devices in a manner that will allow the settings to be restored. If a balancing device is provided with a memory stop, it shall be set and locked.

1.6 SUBMITTALS

A. See Division 23 sections of the Specifications.

B. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 2 copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.

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C. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3 of this section.

D. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 2 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.

E. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this section, on approved forms certified by the testing, adjusting, and balancing Agent.

~~F. Sample Report Forms: Submit 2 sets of sample testing, adjusting, and balancing report forms.~~

~~G.~~F. Warranty: Submit 2 copies of special warranty specified in the "Warranty" Article below.

1.7 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by NEBB.

B. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Architect's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:
    a. Submittal distribution requirements.
    b. Contract Documents examination report.
    c. Testing, adjusting, and balancing plan.
    d. Work schedule and Project site access requirements.
    e. Coordination and cooperation of trades and subcontractors.
    f. Coordination of documentation and communication flow.

C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

D. Testing, Adjusting, and Balancing Reports: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

E. Instrumentation Type, Quantity, and Accuracy: As described in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

1.8 PROJECT SITE CONDITIONS

A. Full Owner Occupancy: The Owner will occupy the site and existing building during the entire testing, adjusting, and balancing period. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

~~B. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.~~

1.9 SEQUENCING AND SCHEDULING

A. The Contractor shall provide the adjusting and balancing agency with one set of the following documents:

1. Within 30 days after approved selection of adjusting and balancing agency:
   a. Contract Drawings.
   b. Applicable Specifications.
   c. Addenda.
2. As Issued: Change Orders.
3. Within 30 days after approval, applicable shop drawings, including the following items:
   a. Sheet metal fabrication and construction drawings.
   b. Equipment manufacturer's submittal data.
   c. Temperature control drawings.

B. Upon receipt of the above listed documents from the Contractor, the adjusting and balancing agency shall evaluate the air and hydronic systems proposed layouts and determine the adequacy of the type, number and location of balancing devices being provided.

C. Any deficiency in the balancing device type, number and location shall be noted by the adjusting and balancing agency and the Contractor shall be so notified.

D. Fabrication and installation of the air and hydronic systems shall not begin until the Contractor has received this report from the adjusting and balancing agency and has taken corrective action.

E. The adjusting and balancing agency shall further be provided with the following:

1. Reasonable time to complete the adjusting and balancing prior to the required completion date.
2. Completely operable systems.
3. The right to adjust the systems.
4. Access to system components.
5. Master keys if the building is occupied.
6. Secure storage space for tools and instruments.

F. The Contractor shall ensure that the adjusting and balancing agency's personnel receive the full cooperation and assistance of the personnel of the pipe fitting, sheet metal and automatic control trades during the adjusting and balancing process.

G. The Contractor shall be responsible for start-up and operation of systems during the adjusting and balancing process. Start-up shall include the following:

1. All equipment operable in safe and normal condition.

2. Automatic control systems installed complete and operable.
3. Proper thermal overload protection in place for electrical equipment.
4. For air systems:
    a. Final filters clean and in place.
    b. Duct systems clean of debris.
    c. Correct fan rotation.
    d. Fire and volume dampers in place and open.
    e. Coil fins combed and cleaned.
    f. Access doors closed and duct end caps in place.
    g. All outlets installed and connected.
    h. Duct system testing completed and leakage not exceeding the rate specified.
5. For Hydronic Systems:
    a. Flushed, filled, and vented.
    ~~b. Correct pump rotation.~~
    ~~c.~~b. Proper strainer baskets clean and in place.
    ~~d.~~c. Temporary start-up strainer baskets removed.
    ~~e.~~d. Service and balance valves open.
    ~~f.~~e. Piping systems testing completed and accepted.

1.10 WARRANTY

A. See Division ~~23~~ 1 sections of the Specifications.

B. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner 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.

C. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
1. The certified Agent has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS

2.1 APPROVED VENDORS

A. UNITED BALANCING
14142 Denver West Parkway Suite 245
Lakewood CO 80401
Office 303-996-8650
Website: www.unitedtab.com

B. TAB SERVICES
2065 South Raritan Street Unit A
Denver CO 80223
Office 303-649-1213
Email: tab@tabservicescolorado.com

C. JPG ENGINEERING
1833 S Mountain View Road
Sedalia, CO 80135
Office 303-688-9044
(No website available)

2.2 EQUIPMENT

A. Instrumentation: Provide air system adjusting and balancing instrumentation such as pitot tubes, flow hoods, incline gauge or U-tube manometers or magnehelic gages, alnor velometer, tachometer or rpm counter, insertion thermometers, clamp-on ammeter for motor voltage and ampere readings and others to be able to completely analyze and balance air handling systems. Instrumentation shall be accurately calibrated and checked before usage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 1 section "Project Record Documents."

D. Examine Architect's and Engineer's 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 equipment performance data, including fan and pump curves. 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. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting specified in individual Specification sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine and identify systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

~~P. Examine open piping system pumps to ensure absence of entrained air in the suction piping.~~

~~Q.~~P. Examine equipment for installation and for properly operating safety interlocks and controls.

~~R.~~Q. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.

6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.

8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.

9. Interlocked systems are operating.

10. Changeover from heating to cooling mode occurs according to design values.

~~S.~~R. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness 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 design conditions for system operations can be met.

3.3 ERECTION, INSTALLATION, APPLICATION

A. General Testing and Balancing Procedures:

1. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this section.

2. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems--Testing, Adjusting, and Balancing" and this section.

3. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

4. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

B. Fundamental Air Systems' Balancing Procedures:

1. 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.
2. Include in the balance report CFM readings for both supply and return/exhaust fans in both the “Full return” and “Full exhaust” damper positions.
3. Prepare schematic diagrams of systems' "as-built" duct layouts.
4. For variable-air-volume systems, develop a plan to simulate diversity.
5. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
6. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
7. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
8. Verify that motor starters are equipped with properly sized thermal protection.
9. Check dampers for proper position to achieve desired airflow path.
10. Check for airflow blockages.
11. ~~Check condensate drains for proper connections and functioning.~~
12. ~~12.~~11. Check for proper sealing of air-handling unit components.

C. Variable-Air-Volume Systems' Additional Procedures:

1. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
2. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
    a. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
    b. 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 duct losses.
    c. Measure total system airflow. Adjust to within 10 percent of design airflow.
    d. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
    e. 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 as described for constant-volume air systems.

1) If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

f. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

g. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure adequate static pressure is maintained at the most critical unit.

h. Record the final fan performance data.

~~3. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:~~

~~a. Balance systems similar to constant-volume air systems.~~

~~b. Set terminal units and supply fan at full-airflow condition.~~

~~c. Adjust inlet dampers of each terminal unit to design airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.~~

~~d. Readjust fan airflow for final maximum readings.~~

~~e. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.~~

~~f. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.~~

~~g. 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 as described for constant-volume air systems.~~

~~1) If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.~~

~~h. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.~~

~~4. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:~~

~~a. Set system at maximum design airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.~~

~~b. Adjust supply fan to maximum design airflow with the variable-airflow controller set at maximum airflow.~~

~~c. Set terminal units being tested at full-airflow condition.~~

~~d. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to design airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.~~

~~e. Adjust terminal units for minimum airflow.~~

~~f. Measure static pressure at the sensor.~~

~~g. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.~~

D. Fundamental Procedures for Hydronic Systems:

1. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
2. Prepare schematic diagrams of systems' "as-built" piping layouts.
3. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
    a. Open all manual valves for maximum flow.
    b. Check expansion tank liquid level.
    c. Check makeup-water-station pressure gage for adequate pressure for highest vent.
    d. Check flow-control valves for specified sequence of operation and set at design flow.
    e. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type, unless several terminal valves are kept open.
    f. Set system controls so automatic valves are wide open to heat exchangers.
    g. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
    h. Check air vents for a forceful liquid flow exiting from vents when manually operated.

E. Hydronic Systems' Balancing Procedures:

1. Determine water flow at pumps. Use the following procedures, except for positive-displacement pumps:
    a. Verify impeller size by operating the pump with the discharge valve closed. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
    b. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.
    c. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
    d. Report flow rates that are not within plus or minus 5 percent of design.
2. Set calibrated balancing valves, if installed, at calculated presettings.
3. Measure flow at all stations and adjust, where necessary, to obtain first balance.

a. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

4. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.

5. Adjust balancing stations to within specified tolerances of design flow rate as follows:

   a. Determine the balancing station with the highest percentage over design flow.

   b. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.

   c. Record settings and mark balancing devices.

6. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.

7. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

F. Variable-Flow Hydronic Systems' Additional Procedures: Balance systems with automatic 2- and 3-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

~~G. Primary-Secondary-Flow Hydronic Systems' Additional Procedures: Balance the primary system crossover flow first, then balance the secondary system.~~

~~H. Heat Exchangers:~~

~~1. Measure water flow through all circuits.~~

~~2. Adjust water flow to within specified tolerances.~~

~~3. Measure inlet and outlet water temperatures.~~

~~4. Measure inlet steam pressure. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves.~~

~~5. Record safety valve settings.~~

~~6. Verify operation of steam traps.~~

~~I.~~G. Motors:

1. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

   a. Manufacturer, model, and serial numbers.

   b. Motor horsepower rating.

   c. Motor rpm.

   d. Efficiency rating if high-efficiency motor.

   e. Nameplate and measured voltage, each phase.

   f. Nameplate and measured amperage, each phase.

   g. Starter thermal-protection-element rating.

2. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove

proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

~~J. Chillers: Balance water flow through each evaporator and condenser to within specified tolerances of design flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:~~

~~1. Evaporator water entering and leaving temperatures, pressure drop, and water flow.~~

~~2. Condenser water entering and leaving temperatures, pressure drop, and water flow.~~

~~3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by the chiller manufacturer.~~

~~4. Power factor if factory-installed instrumentation is furnished for measuring kW.~~

~~5. The kW input if factory-installed instrumentation is furnished for measuring kW.~~

~~6. Capacity: Calculate in tons of cooling.~~

~~7. Air-Cooled Chillers: Verify condenser fan rotation and record fan data, including number of fans and entering- and leaving-air temperatures.~~

~~K. Cooling Towers: Shut off makeup water for the duration of the test, and then make sure the makeup and blow-down systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:~~

~~1. Measure condenser water flow to each cell of the cooling tower.~~

~~2. Measure entering- and leaving-water temperatures.~~

~~3. Measure wet- and dry-bulb temperatures of entering air.~~

~~4. Measure wet- and dry-bulb temperatures of leaving air.~~

~~5. Measure condenser water flow rate recirculating through the cooling tower.~~

~~6. Measure cooling tower pump discharge pressure.~~

~~7. Adjust water level and feed rate of makeup-water system.~~

~~L. Condensing Units: Verify proper rotation of fans and measure entering- and leaving-air temperatures. Record compressor data.~~

~~M.~~H. Boilers: Measure entering- and leaving-water temperatures and water flow.

~~N.~~I. Heat-Transfer Coils:

1. Water Coils: Measure the following data for each coil:
   a. Entering- and leaving-water temperatures.
   b. Water flow rate.
   c. Water pressure drop.
   d. Dry-bulb temperatures of entering and leaving air.
   e. Wet-bulb temperatures of entering and leaving air for cooling coils designed for less than 7500 cfm.
   f. Airflow.

g. Air pressure drop.

~~2. Electric-Heating Coils: Measure the following data for each coil:~~

~~a. Nameplate data.~~

~~b. Airflow.~~

~~c. Entering- and leaving-air temperatures at full load.~~

~~d. Voltage and amperage input of each phase at full load and at each incremental stage.~~

~~e. Calculated kW at full load.~~

~~f. Fuse or circuit-breaker rating for overload protection.~~

~~O. Temperature Testing:~~

~~1. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.~~

~~2. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive 8-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.~~

~~3. Measure outside-air, wet- and dry-bulb temperatures.~~

~~P. Fume Hoods: Determine total airflow into the room where the fume hood is located and balance systems to ensure adequate air supply to all hoods.~~

~~1. Set fume-hood door opening at position of normal use.~~

~~2. Energize the exhaust fan and adjust airflow to provide the indicated average fume-hood face velocity at hood opening.~~

~~3. Measure exhaust airflow volume by measuring airflow by Pitot-tube duct traverse.~~

~~4. Measure air velocity using Pitot-tube traverse method.~~

~~5. Record each face velocity measurement taken at 4- to 6-inch increments over the entire hood door opening.~~

~~6. Calculate the average face velocity by averaging all velocity measurements.~~

~~7. Calculate the airflow volume of exhaust-hood face velocity by multiplying the calculated average face velocity by the opening area. Compare this quantity with exhaust volume at exhaust fan and report duct leakage.~~

~~8. Measure airflow volume supplied by makeup fan. Verify that the makeup system supplies the proper amount of air to keep the space at the indicated pressure with the exhaust systems in all operating conditions.~~

~~9. Retest for average face velocity. Adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity and the indicated auxiliary air-supply percentages.~~

~~10. Retest and adjust the systems until fume-hood performance complies with Contract Documents.~~

~~Q.~~J. Temperature-Control Verification:

1. Verify that controllers are calibrated.

2. Check transmitter and controller locations and note conditions that would adversely affect control functions.
3. Record controller settings and note variances between set points and actual measurements.
4. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).
5. Verify free travel and proper operation of control devices such as damper and valve operators.
6. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.
7. Confirm interaction of electrically operated switch transducers.
8. Confirm interaction of interlock and lockout systems.
9. Verify main control supply-air pressure and observe compressor and dryer operations.
10. Record voltages of power supply and controller output. Determine if the system operates on a grounded or nongrounded power supply.
11. Note operation of electric actuators using spring return for proper fail-safe operations.

~~R.~~K. Tolerances: Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans: 0 to plus 10 percent.
2. Air Outlets and Inlets:

Positive Zones		Negative Zones	
Supply Air	0 to +10%	Supply Air	0 to –10%
Exh/Ret Air	0 to –10%	Exh/Ret Air	0 to +10%

Note: When spaces are balanced to the above criteria, the differential between air in and air out must be maintained.

3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. ~~Cooling-Water Flow Rate: 0 to minus 5 percent.~~

~~S.~~L. Reporting:

1. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, 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.
2. ~~Status Reports: As Work progresses, prepare 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.~~

~~T.~~M. Final Report:

1. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

2. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
    a. Include a list of the instruments used for procedures, along with proof of calibration.
3. Final Report Contents: In addition to the certified field report data, include the following:
    a. Pump curves.
    b. Fan curves.
    c. Manufacturers' test data.
    d. Field test reports prepared by system and equipment installers.
    e. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.
4. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:
    a. Title page.
    b. Name and address of testing, adjusting, and balancing Agent.
    c. Project name.
    d. Project location.
    e. Architect's name and address.
    f. Engineer's name and address.
    g. Contractor's name and address.
    h. Report date.
    i. Signature of testing, adjusting, and balancing Agent who certifies the report.
    j. Summary of contents, including the following:
        1) Design versus final performance.
        2) Notable characteristics of systems.
        3) Description of system operation sequence if it varies from the Contract Documents.
    k. Nomenclature sheets for each item of equipment.
    l. Data for terminal units, including manufacturer, type size, and fittings.
    m. Notes to explain why certain final data in the body of reports vary from design values.
    n. Test conditions for fans and pump performance forms, including the following:
        1) Settings for outside-, return-, and exhaust-air dampers.
        2) Conditions of filters.
        ~~3) Cooling coil, wet- and dry-bulb conditions.~~
        ~~4) Face and bypass damper settings at coils.~~

~~5)~~3) Fan drive settings, including settings and percentage of maximum pitch diameter.

~~6) Inlet vane settings for variable-air-volume systems.~~

~~7)~~4) Settings for supply-air, static-pressure controller.

~~8)~~5) Other system operating conditions that affect performance.

5. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
   a. Quantities of outside, supply, return, and exhaust airflows.
   b. Water ~~and steam~~ flow rates.
   c. Duct, outlet, and inlet sizes.
   d. Pipe and valve sizes and locations.
   e. Terminal units.
   f. Balancing stations.
6. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
   a. Unit Data: Include the following:
      1) Unit identification.
      2) Location.
      3) Make and type.
      4) Model number and unit size.
      5) Manufacturer's serial number.
      6) Unit arrangement and class.
      7) Discharge arrangement.
      8) Sheave make, size in inches, and bore.
      9) Sheave dimensions, center-to-center and amount of adjustments in inches.
      10) Number of belts, make, and size.
      11) Number of filters, type, and size.
   b. Motor Data: Include the following:
      1) Make and frame type and size.
      2) Horsepower and rpm.
      3) Volts, phase, and hertz.
      4) Full-load amperage and service factor.
      5) Sheave make, size in inches, and bore.
      6) Sheave dimensions, center-to-center and amount of adjustments in inches.
   c. Test Data: Include design and actual values for the following:
      1) Total airflow rate in cfm.

2) Total system static pressure in inches wg.
3) Fan rpm.
4) Discharge static pressure in inches wg.
5) Filter static-pressure differential in inches wg.
6) Preheat coil static-pressure differential in inches wg.
7) Cooling coil static-pressure differential in inches wg.
8) Heating coil static-pressure differential in inches wg.
9) Outside airflow in cfm.
10) Return airflow in cfm.
11) Outside-air damper position.
12) Return-air damper position.
~~13) Vortex damper position.~~

~~7. Apparatus Coil Test Reports: For apparatus coils, include the following:~~

~~a. Coil Data: Include the following:~~

~~1) System identification.~~
~~2) Location.~~
~~3) Coil type.~~
~~4) Number of rows.~~
~~5) Fin spacing in fins per inch.~~
~~6) Make and model number.~~
~~7) Face area in sq. ft.~~
~~8) Tube size in DN.~~
~~9) Tube and fin materials.~~
~~10) Circuiting arrangement.~~

~~b. Test Data: Include design and actual values for the following:~~

~~1) Airflow rate in cfm.~~
~~2) Average face velocity in fpm.~~
~~3) Air pressure drop in inches wg.~~
~~4) Outside air, wet- and dry-bulb temperatures in deg F.~~
~~5) Return air, wet- and dry-bulb temperatures in deg F.~~
~~6) Entering air, wet- and dry-bulb temperatures in deg F.~~
~~7) Leaving air, wet- and dry-bulb temperatures in deg F.~~
~~8) Water flow rate in gpm.~~
~~9) Water pressure differential in feet of head or psig.~~
~~10) Entering water temperature in deg F.~~

11) Leaving water temperature in deg F.

12) Refrigerant expansion valve and refrigerant types.

13) Refrigerant suction pressure in psig.

14) Refrigerant suction temperature in deg F.

15) Inlet steam pressure in psig.

8. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to the manufacturer's factory startup equipment reports, include the following:

a. Unit Data: Include the following:

1) System identification.

2) Location.

3) Make and type.

4) Model number and unit size.

5) Manufacturer's serial number.

6) Fuel type in input data.

7) Output capacity in Btuh.

8) Ignition type.

9) Burner control types.

10) Motor horsepower and rpm.

11) Motor volts, phase, and hertz.

12) Motor full-load amperage and service factor.

13) Sheave make, size in inches, and bore.

14) Sheave dimensions, center-to-center and amount of adjustments in inches.

b. Test Data: Include design and actual values for the following:

1) Total airflow rate in cfm.

2) Entering air temperature in deg F.

3) Leaving air temperature in deg F.

4) Air temperature differential in deg F.

5) Entering air static pressure in inches wg.

6) Leaving air static pressure in inches wg.

7) Air static pressure differential in (inches wg.

8) Low-fire fuel input in Btuh.

9) High-fire fuel input in Btuh.

10) Manifold pressure in psig.

11) High-temperature-limit setting in deg F.

12) Operating set point in Btuh.

13) Motor voltage at each connection.

14) Motor amperage for each phase.

15) Heating value of fuel in Btuh.

9. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

a. Unit Data: Include the following:

1) System identification.

2) Location.

3) Coil identification.

4) Capacity in Btuh.

5) Number of stages.

6) Connected volts, phase, and hertz.

7) Rated amperage.

8) Airflow rate in cfm.

9) Face area in sq. ft.

10) Minimum face velocity in fpm.

b. Test Data: Include design and actual values for the following:

1) Heat output in Btuh.

2) Airflow rate in cfm.

3) Air velocity in fpm.

4) Entering-air temperature in deg F.

5) Leaving-air temperature in deg F.

6) Voltage at each connection.

7) Amperage for each phase.

10. Fan Test Reports: For supply, return, and exhaust fans, include the following:

a. Fan Data: Include the following:

1) System identification.

2) Location.

3) Make and type.

4) Model number and size.

5) Manufacturer's serial number.

6) Arrangement and class.

7) Sheave make, size in inches, and bore.

8) Sheave dimensions, center-to-center and amount of adjustments in inches.

b. Motor Data: Include the following:

~~1) Make and frame type and size.~~

~~2) Horsepower and rpm.~~

~~3) Volts, phase, and hertz.~~

~~4) Full-load amperage and service factor.~~

~~5) Sheave make, size in inches, and bore.~~

~~6) Sheave dimensions, center-to-center and amount of adjustments in inches.~~

~~7) Number of belts, make, and size.~~

~~c. Test Data: Include design and actual values for the following:~~

~~1) Total airflow rate in cfm.~~

~~a) Total system static pressure in inches wg.~~

~~b) Fan rpm.~~

~~c) Discharge static pressure in inches wg.~~

~~d) Suction static pressure in inches wg.~~

~~11.~~7. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

a. Report Data: Include the following:

1) System and air-handling unit number.

2) Location and zone.

3) Traverse air temperature in deg F.

4) Duct static pressure in Inches wg.

5) Duct size in inches.

6) Duct area in sq. m (sq. ft.).

7) Design airflow rate in Cfm.

8) Design velocity in m/s (fpm).

9) Actual airflow rate in Cfm.

10) Actual average velocity in m/s (fpm).

11) Barometric pressure in Pa (psig).

~~12.~~8. Air-Terminal-Device Reports: For terminal units, include the following:

a. Unit Data: Include the following:

1) System and air-handling unit identification.

2) Location and zone.

3) Test apparatus used.

4) Area served.

5) Air-terminal-device make.

6) Air-terminal-device number from system diagram.

7) Air-terminal-device type and model number.

8) Air-terminal-device size.

9) Air-terminal-device effective area in sq. m (sq. ft.).

b. Test Data: Include design and actual values for the following:

1) Airflow rate in cfm.

2) Air velocity in m/s (fpm).

3) Preliminary airflow rate as needed in cfm.

4) Preliminary velocity as needed in m/s (fpm).

5) Final airflow rate in cfm.

6) Final velocity in m/s (fpm).

7) Space temperature in deg F.

~~13.~~9. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

a. Unit Data: Include the following:

1) System and air-handling unit identification.

2) Location and zone.

3) Room or riser served.

4) Coil make and size.

5) Flowmeter type.

b. Test Data: Include design and actual values for the following:

1) Airflow rate in cfm.

2) Entering-water temperature in deg F.

3) Leaving-water temperature in deg F.

4) Water pressure drop in feet of head or psig.

5) Entering-air temperature in deg F.

6) Leaving-air temperature in deg F.

~~14. Packaged Chiller Reports: For each chiller, include the following:~~

~~a. Unit Data: Include the following:~~

~~1) Unit identification.~~

~~2) Make and model number.~~

~~3) Manufacturer's serial number.~~

~~4) Refrigerant type and capacity in gal. (L).~~

~~5) Starter type and size.~~

~~6) Starter thermal protection size.~~

~~b. Condenser Test Data: Include design and actual values for the following:~~

1) Refrigerant pressure in Btuh.

2) Refrigerant temperature in deg F.

3) Entering-water temperature in deg F.

4) Leaving-water temperature in deg F.

5) Entering-water pressure in feet of head or psig.

6) Water pressure differential in feet of head or psig.

c. Evaporator Test Reports: Include design and actual values for the following:

1) Refrigerant pressure in Btuh.

2) Refrigerant temperature in deg F.

3) Entering-water temperature in deg F.

4) Leaving-water temperature in deg F.

5) Entering-water pressure in feet of head or psig.

6) Water pressure differential in feet of head or psig.

d. Compressor Test Data: Include design and actual values for the following:

1) Make and model number.

2) Manufacturer's serial number.

3) Suction pressure in Btuh.

4) Suction temperature in deg F.

5) Discharge pressure in Btuh.

6) Discharge temperature in deg F.

7) Oil pressure in Btuh.

8) Oil temperature in deg F.

9) Voltage at each connection.

10) Amperage for each phase.

11) The kW input.

12) Crankcase heater kW.

13) Chilled-water control set point in deg F.

14) Condenser-water control set point in deg F.

15) Refrigerant low-pressure cutoff set point in Btuh.

16) Refrigerant high-pressure cutoff set point in Btuh.

e. Refrigerant Test Data: Include design and actual values for the following:

1) Oil level.

2) Refrigerant level.

3) Relief valve setting in Btuh.

4) Unloader set points in Btuh.

5) Percentage of cylinders unloaded.

6) Bearing temperatures in deg F.

7) Vane position.

8) Low-temperature cutoff set point in deg F.

15. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:

a. Unit Data: Include the following:

1) Unit identification.

2) Location.

3) Unit make and model number.

4) Manufacturer's compressor serial numbers.

5) Compressor make.

6) Compressor model and serial numbers.

7) Refrigerant weight in kg (lb).

8) Low ambient temperature cutoff in deg F.

b. Test Data: Include design and actual values for the following:

1) Inlet duct static pressure in Inches wg.

2) Outlet duct static pressure in Inches wg.

3) Entering-air, dry-bulb temperature in deg F.

4) Leaving-air, dry-bulb temperature in deg F.

5) Condenser entering-water temperature in deg F.

6) Condenser leaving-water temperature in deg F.

7) Condenser water temperature differential in deg F.

8) Condenser entering-water pressure in feet of head or psig.

9) Condenser leaving-water pressure in feet of head or psig.

10) Condenser water pressure differential in feet of head or psig.

11) Control settings.

12) Unloader set points.

13) Low-pressure cutout set point in Btuh.

14) High-pressure cutout set point in Btuh.

15) Suction pressure in Btuh.

16) Suction temperature in deg F.

17) Condenser refrigerant pressure in Btuh.

18) Condenser refrigerant temperature in deg F.

19) Oil pressure in Btuh.

20) Oil temperature in deg F.

21) Voltage at each connection.

22) Amperage for each phase.

23) The kW input.

24) Crankcase heater kW.

25) Number of fans.

26) Condenser fan rpm.

27) Condenser fan airflow rate in Cfm.

28) Condenser fan motor make, frame size, rpm, and horsepower.

29) Condenser fan motor voltage at each connection.

30) Condenser fan motor amperage for each phase.

16. Cooling Tower or Condenser Test Reports: For cooling towers or condensers, include the following:

a. Unit Data: Include the following:

1) Unit identification.

2) Make and type.

3) Model and serial numbers.

4) Nominal cooling capacity in kW (tons).

5) Refrigerant type and weight in kg (lb).

6) Water-treatment chemical feeder and chemical.

7) Number and type of fans.

8) Fan motor make, frame size, rpm, and horsepower.

9) Fan motor voltage at each connection.

10) Sheave make, size in inches, and bore.

11) Sheave dimensions, center-to-center and amount of adjustments in inches.

12) Number of belts, make, and size.

b. Pump Test Data: Include design and actual values for the following:

1) Make and model number.

2) Manufacturer's serial number.

3) Motor make and frame size.

4) Motor horsepower and rpm.

5) Voltage at each connection.

6) Amperage for each phase.

7) Water flow rate in gpm.

c. Water Test Data: Include design and actual values for the following:

1) Entering-water temperature in deg F.

2) Leaving-water temperature in deg F.

3) Water temperature differential in deg F.

4) Entering-water pressure in feet of head or psig.

5) Leaving-water pressure in feet of head or psig.

6) Water pressure differential in feet of head or psig.

7) Water flow rate in gpm.

8) Bleed water flow rate in gpm.

d. Air Data: Include design and actual values for the following:

1) Duct airflow rate in Cfm.

2) Inlet-duct static pressure in Inches wg.

3) Outlet-duct static pressure in Inches wg.

4) Average entering-air, wet-bulb temperature in deg F.

5) Average leaving-air, wet-bulb temperature in deg F.

6) Ambient wet-bulb temperature in deg F.

17. Heat Exchanger/Converter Test Reports: For steam and hot-water heat exchangers, include the following:

a. Unit Data: Include the following:

1) Unit identification.

2) Location.

3) Service.

4) Make and type.

5) Model and serial numbers.

6) Ratings.

b. Steam Test Data: Include design and actual values for the following:

1) Inlet pressure in Btuh.

2) Condensate flow rate in gpm.

c. Primary Water Test Data: Include design and actual values for the following:

1) Entering-water temperature in deg F.

2) Leaving-water temperature in deg F.

3) Entering-water pressure in feet of head or psig.

4) Water pressure differential in feet of head or psig.

5) Water flow rate in gpm.

d. Secondary Water Test Data: Include design and actual values for the following:

~~1) Entering water temperature in deg F.~~

~~2) Leaving water temperature in deg F.~~

~~3) Entering water pressure in feet of head or psig.~~

~~4) Water pressure differential in feet of head or psig.~~

~~5) Water flow rate in gpm.~~

~~18.~~10. Pump Test Reports: For pumps, include the following data. Calculate impeller size by plotting the shutoff head on pump curves.

a. Unit Data: Include the following:

1) Unit identification.
2) Location.
3) Service.
4) Make and size.
5) Model and serial numbers.
6) Water flow rate in gpm.
7) Water pressure differential in feet of head or psig.
8) Required net positive suction head in feet of head or psig.
9) Pump rpm.
10) Impeller diameter in inches.
11) Motor make and frame size.
12) Motor horsepower and rpm.
13) Voltage at each connection.
14) Amperage for each phase.
15) Full-load amperage and service factor.
16) Seal type.

b. Test Data: Include design and actual values for the following:

1) Static head in feet of head or psig.
2) Pump shutoff pressure in feet of head or psig.
3) Actual impeller size in inches.
4) Full-open flow rate in gpm.
5) Full-open pressure in feet of head or psig.
6) Final discharge pressure in feet of head or psig.
7) Final suction pressure in feet of head or psig.
8) Final total pressure in feet of head or psig.
9) Final water flow rate in gpm.
10) Voltage at each connection.

11) Amperage for each phase.

c. Pump Impeller Trimming for Energy Conservation: After systems with constant speed base mounted centrifugal pumps, 15 hp and larger, have been adjusted and balanced, using flow and amperage readings and the pump curves, determine whether a minimum of 3 horsepower could be saved by impeller trimming in accordance with ASHRAE Standard 90.1. If such is the case, submit results for approval prior to advising the installing contractor of the amount of trimming required.

~~19.~~11. Boiler Test Reports: For boilers, include the following:

a. Unit Data: Include the following:

1) Unit identification.

2) Location.

3) Service.

4) Make and type.

5) Model and serial numbers.

6) Fuel type and input in Btuh.

7) Number of passes.

8) Ignition type.

9) Burner-control types.

10) Voltage at each connection.

11) Amperage for each phase.

b. Test Data: Include design and actual values for the following:

1) Operating pressure in Btuh.

2) Operating temperature in deg F.

3) Entering-water temperature in deg F.

4) Leaving-water temperature in deg F.

5) Number of safety valves and sizes in NPS.

6) Safety valve settings in Btuh.

7) High-limit setting in Btuh.

8) Operating-control setting.

9) High-fire set point.

10) Low-fire set point.

11) Voltage at each connection.

12) Amperage for each phase.

13) Draft fan voltage at each connection.

14) Draft fan amperage for each phase.

15) Manifold pressure in Btuh.

~~U.~~N. Additional Tests:

1. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
2. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230594
TESTING OF PIPING SYSTEMS

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 SUMMARY

A. This Section includes the provision of all labor material and equipment to test all the piping systems on the Project.

1.3 SYSTEM DESCRIPTION

A. Performance Requirements: Test all piping systems provided under Division 23 sections of the Specifications.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Provide pumps, gages, valves, piping, flanges, blanks and other equipment and material necessary to properly conduct the tests. Check gages used for pressure tests against a dead weight tester and certify correct over the range of the gage.

B. Repair defects appearing during tests immediately with new material, at the Contractor's expense, and re-test the lines to prove elimination of defects.

PART 3 - EXECUTION

3.1 ERECTION, INSTALLATION, APPLICATION

A. General Requirements:

1. Test and adjust all parts of each system and associated equipment to work properly and leave in good operating condition.
2. Notify the Architect in advance of all tests, so that the Architect may be represented at all tests, and determine that all tests are conducted to the Architect's entire satisfaction.
3. Repair or replace all defects disclosed in the work by tests or otherwise uncovered without additional cost to the Owner.
4. Repeat tests after any defects disclosed and repair or replace, if in the judgment of the Architect, it is deemed necessary.
5. Make all repairs to piping systems with new material. No caulking on screwed joints, cracks, or holes will be acceptable. Where it becomes necessary to replace pieces of pipe, make such replacement with the same lengths as the defective pieces.
6. Arrange for and pay the cost of all utilities used on tests.
7. Make all tests before piping is concealed and covering is applied.
8. Take all necessary precautions and protections required when testing to protect all devices, equipment and specialties when test pressures exceed the pressure testing limitations of such items.

~~B. Underground Pipe Testing:~~

~~1. General: Make required tests on underground piping included in this Contract. Make tests before backfilling is started.~~

~~C.~~B. Aboveground Pipe Testing:

1. General:

   a. Include in the testing requirements for the respective piping systems, applicable governing codes and insurance company requirements, and those specified. Forward a copy of code-required plumbing inspection certificates for approval.

   b. Make specified pressure tests as outlined below on piping included in this Contract. Make tests before piping is painted, covered, or concealed.

   c. Ensure that joints on lines under liquid pressure remain drop dry for a period of one hour under test pressure. Ensure that exterior surface of pipe and fittings do not show cracks, other forms of leaks, or permanent deformation. Drain pipe, other than water pipe, completely after test.

   d. Observe the tests after the pipe and contents have assumed ambient temperature and the source of the test pressure shut off.

2. Pressure Tests on Service Piping :

System	**Type of Test**	**Test Pressure psi**	**Permissible Pressure Drop psi**
~~Steam (60 psi)~~	~~Water~~	~~225~~	~~3 2 hours~~
~~Steam (60 psi) and under~~	~~Water~~	~~100~~	~~1 2 hours~~
~~Condensate~~	~~Water~~	~~150~~	~~2 2 hours~~
~~Chilled water~~	~~Water~~	~~150~~	~~2 2 hours~~
~~Condenser water~~	~~Water~~	~~1034 (150)~~	~~2 2 hours~~
Heating hot water	Water	150	2 – 2 hours
~~Glycol~~	~~Water~~	~~150~~	~~2 hours~~

   a. Air Test:

      1) Make a preliminary test at 25 psig. If the piping is found not to have any major leaks, than slowly increase the pressure in increments of 25 psig with 10 minutes allowed between increased pressurization for free equalization, until the test pressure is reached.

      2) Do not exceed pressure drop specified above.

      3) When possible, make tests when ambient air temperature is approximately constant.

      4) Make corrections for pressure difference due to temperature changes.

      5) Use the following formula to determine air pressure change due to temperature change:

         a) $[14.7 + P1]/[14.7 + P2] = [460 + T1]/[460 + T2]$

         b) P = Pressure - psi gage. T = Temperature - degrees F.

6) Charge piping systems with air to the pressure specified and examine joints for leaks with a soapsuds solution.

b. Water Test:

1) Remove from the piping such items as steam traps, diaphragm valves, and any other devices not designed to withstand the test pressure.

2) Remove from the piping, all restrictions, such as flow nozzles and orifice plates, which interfere with filling, venting, or draining.

3) Open all vents and other connections which can serve as vents during filling, so that all air is vented prior to applying test pressure.

4) Provide piping systems designed for steam with additional temporary supports if necessary to support the weight of the test liquid.

5) Place automatic control valves in the open position unless they are provided with a by-pass permitting application of pressure to both sides.

6) Insert travel stops in spring hanger pipe supports.

7) Provide expansion joints with temporary restraints if required for the additional pressure load under test, or isolated during the pressure test.

8) Provide piping systems subject to extended hydrostatic test periods with a protective device to relieve excess pressure due to thermal expansion.

9) Slowly charge systems receiving this test with water to the pressure specified. Ensure that exterior surface of pipe and fitting does not show cracks or other forms of leaks and shall be completely drop dry.

END OF SECTION 230594

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SECTION 230700
HVAC INSULATION

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 SUMMARY

A. This Section includes the thermal insulation for heated and cooled mechanical equipment, piping and ductwork provided in other Division 23 sections of the Specifications.

1.3 REFERENCES

A. American Society of Testing and Materials (ASTM)

1. C165 - Test Method for Measuring Compressive Properties of Thermal Insulations.
2. C177 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
3. C203 - Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation.
4. C209 - Test Methods for Cellulosic Insulating Board.
5. C240 - Test Method of Testing Cellular Glass Insulation Block.
6. C272 - Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions.
7. C273 – Test Method for Shear Properties of Sandwich Core Materials.
8. C302 - Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
9. C303 - Test Method for Density of Preformed Block-Type Thermal Insulation.
10. C335 - Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
11. C356 - Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat.
12. C411 - Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
13. C421 - Test Method for Tumbling Friability of Preformed Block-Type Thermal Insulation.
14. C450 – Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
15. C518 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
16. C533 - Specification for Calcium Silicate Block and Pipe Thermal Insulation.
17. C547 - Specification for Mineral Fiber Preformed Pipe Insulation.
18. C552 - Specification for Cellular Glass Thermal Insulation.
19. C585 – Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS) System.

20. C591 - Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
21. C610 - Specification for Expanded Perlite Block and Pipe Thermal Insulation.
22. C612 - Specification for Mineral Fiber Block and Board Thermal Insulation.
23. C623 - Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance.
24. C755 - Practice for Selection of Vapor Retarders for Thermal Insulation.
25. C795 - Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
26. C921 - Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
27. C1126 - Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.
28. C1136 - Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
29. D635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.
30. D696 – Test Method for Coefficient of Thermal Expansion of Plastics Between –30o C and 30o C.
31. D1056 - Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
32. D1149 - Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber.
33. D1622 - Test Method for Apparent Density of Rigid Cellular Plastics.
34. D1784 - Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
35. D2842 - Test Method for Water Absorption of Rigid Cellular Plastics.
36. E96 - Test Method for Water Vapor Transmission Materials.
37. E119 - Method for Fire Tests of Building Construction and Materials.
38. E136 - Test Method for Behavior of Materials in a Vertical Tube Furnace at 750oC.
39. E228 - Test Method for Linear Thermal Expansion of Solid Materials With a Vitreous Silica Dilatometer.

B. Midwest Insulation Contractors Association (MICA)
   1. National Commercial and Industrial Insulation Standards.

C. National Fire Protection Association (NFPA)
   1. 90A - Standard for Installation of Air-Conditioning and Ventilating Systems.
   2. 90B - Installation of Warm Air Heating and Air Conditioning Systems.

D. Underwriters Laboratories Inc. (UL)
   1. 790 - Test for Fire Resistance of Roof Covering Materials.

1.4 DEFINITION OF LOCATIONS SCHEDULE

A. Finished and Unfinished Areas

1. "Finished areas" are areas where floor, walls, ceilings, trim, or exposed steel are painted, tiled, or similarly finished.

2. "Unfinished areas" are areas with unpainted walls.

B. Exposed and Concealed Areas

1. "Exposed areas" are finished areas and other areas used by personnel in the normal use of the building, such as boiler room, fan rooms, mechanical rooms, and storage rooms.

2. "Concealed areas" are pipe tunnels, covered pipe trenches, spaces inside walls, duct or pipe shafts, spaces above dropped ceilings, unfinished attic spaces, crawl spaces, and space below access floor.

1.5 SYSTEM DESCRIPTION

A. Design Requirements

1. Heated piping systems to be insulated

a. Hot water heating supply and return.

2. Heated piping systems and components not to be insulated

a. Heating water piping within enclosures of finned radiation, convectors and heating and ventilating units.

b. Vents to atmosphere, discharges from safety and relief valves, except where burn protection for operating personnel dictates.

c. Overflow and drain lines from heating equipment.

d. Unions in all locations.

~~3. Ambient and chilled piping systems to be insulated~~

~~a. Chilled water supply and return.~~

~~b. Glycol heat recovery supply and return~~

~~c. Drain lines from cooling coil drain pans not located in mechanical equipment rooms.~~

~~d. Condenser water (when cooling tower is used for water side economizer only).~~

~~4. Heated equipment to be insulated~~

~~a. Converters and heat exchangers.~~

~~b. Heating hot water expansion tanks.~~

~~c. Air separators.~~

~~5. Ambient and chilled equipment to be insulated.~~

~~a. Chilled water tanks including expansion tanks and air separators.~~

~~b. Refrigeration machine components.~~

~~c. Chilled water pumps.~~

~~d. Chilled water heat exchangers.~~

~~e. Cooling coil drain pans.~~

~~6.~~3. Air handling apparatus and ductwork to be insulated

~~a. Outside air intake plenums and ducts.~~

~~b.~~a. Air conditioning supply ducts outside of conditioned space.

~~c. Re-heat coil casings and return bends in ductwork and at air terminal units above non-plenum ceilings and non-conditioned spaces only.~~

~~d. Supply air diffuser bodies in non-plenum ceiling spaces.~~

~~e.~~b. Return air ducts for air conditioning systems in mechanical equipment rooms and exposed in non-air conditioned spaces, in ceiling cavities over non-air conditioned spaces or outdoor locations.

~~f. Relief air ducts downstream of the relief air damper.~~

~~g.~~c. Heating and ventilating supply ducts.

~~7. Air handling apparatus and ductwork not to be insulated~~

~~a. Double-wall air handling unit housings and plenums.~~

~~b. Air conditioning ducts exposed to view in air conditioned areas.~~

1.6 SUBMITTALS

A. Refer to requirements in Division 23, "Common Work Results for HVAC."

B. Product Data

1. Submit description, heat transfer coefficients, characteristics, and compliance with specified flame spread and smoke development ratings for insulation, jackets and adhesives on insulated systems.

~~**NOTE: DESIGN CONSULTANT TO PROVIDE MATERIAL SPECIFICATION SHEETS (CUT SHEETS) AS PART OF DESIGN CALCULATIONS & ANALYSIS DELIVERABLE**~~

C. Schedules

1. Submit schedules of thicknesses for each insulated system, including each pipe size for each insulated piping system.

~~D. Samples~~

~~1. Submit Samples of each type of insulation and insulation system proposed for use on the Project.~~

1.7 STORAGE AND HANDLING

A. Store insulation and accessory materials in a manner that protects them from damage due to moisture and temperature. Store all flammable materials away from ignition sources such as welding operations.

B. Store mastics, adhesives and sealers where temperature ranges required by the material manufacturer can be maintained.

C. Keep all insulation material dry and off the ground and provide adequate protection against moisture and inadequate drainage. Remove and replace wet or damaged material.

1.8 WARRANTY

A. Refer to requirements in Division 23, "Common Work Results for HVAC."

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide insulation, binders, vapor barriers, jackets, adhesives, coatings, tapes and sealers furnished under this section which are listed and labeled by a nationally recognized certifying organization such as Underwriters Laboratories Inc., OmegaPoint, or Southwest Research Institute as having a flame spread rating of 25 or less and smoke development rating of 50 or less when tested in accordance with ASTM E84, unless otherwise specified.

B. Provide pipe insulation in pre-molded, 3- or 6-foot-long sections, split ready for application or split with factory applied vapor barrier attached.

C. Do not use wheat paste, mold-breeding and mold-sustaining organic materials.

D. Provide insulation materials which are 100 percent asbestos free.

2.2 MANUFACTURERS

A. Fiberglass Insulation

1. Owens-Corning Fiberglas Corporation; Johns Manville; Manson Insulation, Inc.; or Knauf Fiber Glass.

~~B. Cellular Glass Insulation~~

~~1. Pittsburgh Corning Corporation "Foamglas"; Cell-U-Foam Corp. "Ultra-CUF-1031".~~

~~C. Calcium Silicate Insulation~~

~~1. Johns Manville "Thermo-Gold" or Calsilite Group "Calsilite".~~

~~D. Ceramic Fiber Insulation~~

~~1. Johns Manville "Super Firetemp" wrap; Great Lakes Textiles, Inc. "Firestop Blanket"; or Unifrax Corporation "FyreWrap".~~

~~E. Phenolic Foam Insulation~~

~~1. Tarec Insulation, Cape Insulation Products, Kingspan Corp.~~

~~F. Expanded Perlite Insulation~~

~~1. Knauf "Temperlite 1200"; Calsilite Group "Sproule WR-1200 Perlite".~~

~~G. Mineral Wool Insulation~~

~~1. Fibrex Insulations Inc.; Owens Corning "Paroc"; Roxul "1200"; Rock Wool Mfg. Co. "Delta PF" or "Delta PC".~~

~~H. Polyisocyanurate (PIR) Unfaced Rigid Insulation~~

~~1. The Dow Chemical Company "TRYMER* 2000"; Tarec "Ecopir 33"; Apache "Iso 25".~~

~~I. Extruded Foamed Polystyrene (XPS) Thermal Insulation~~

~~1. The Dow Chemical Company "STYROFOAM*PIB"; Owens Corning "Foamular 250". NOTE: This material does NOT meet the 25/50 flame/smoke requirement and should only be used where permitted by code.~~

~~J.~~B. Adhesives, Mastics, Coatings and Sealants

1. Foster Products Div., H.B. Fuller Co.; I-C Adhesives Co.; Chicago Mastic Co.; Childers Products Co. or St. Clair Rubber Co.; and as specified in Part 3 - Execution.

~~K.~~C. Vapor Barriers

1. Ambient and chilled systems indoor: All Service Jacket (ASJ) consisting of 0.00035 inch thick aluminum foil laminated to two sheets of Kraft paper by flame retardant adhesive or 0.001-inch–thick aluminum foil. Provide the complete laminated product reinforced with yarn spacing at 5 per inch, Dow “Saran 540” or VyTech “Atlas VRP”.

~~2. Ambient and chilled systems outdoor and cold systems indoor and outdoor: Dow “Saran 560”, Alpha “Alaflex Style 13 MAM” or Polyguard “Insulrap 30”~~

~~L.~~D. Jacketing

1. Indoor general: 20-mil-thick pvc with 25/50 flame and smoke per ASTM E84. Indoor cold piping and equipment: 0.030-inch with 25/50 flame and smoke per ASTM E84.

~~M. Outdoor Waterproofing~~

~~1. Smooth aluminum jacketing, 0.016 inch thick for pipe and 0.024 inch thick with vapor barrier for equipment.~~

2.3 PIPE INSULATION SCHEDULE

A. Glass fiber, pre-formed, rigid, molded insulation with vapor barrier consisting of white Kraft paper reinforced with glass fiber yarn and bonded to aluminum foil, with self-sealing longitudinal laps and butt strips. Provide insulation with a thermal conductivity 'k' of 0.23 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature with a minimum service temperature of 55 degrees F and a maximum service temperature of 850 degrees F. Provide insulation and jacketing conforming to the following standards:

ASTM C335, C356, C411, C518, C547, C795, C1136.

~~B. Cellular glass insulation with vapor barrier consisting of inorganic, foamed or cellular glass, annealed, rigid hermetically sealed cells with an ASTM C921, Type 1, factory-applied, polymer-modified bituminous compound reinforced with a 4-mil, high density, cross laminate, polyethylene top film. Provide insulation with a thermal conductivity 'k' of 0.32 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature with a minimum service temperature of -60 degrees F and a maximum service temperature of 900 degrees F. Provide insulation and jacketing conforming to the following standards:~~

~~ASTM C177, C203, C240, C303, C518, C552, C623, E96, E228.~~

~~C. Pre-formed half-cylinder felted mineral wool insulation bonded with a high temperature binder, with a thermal conductivity ‘k’ of 0.24 BTU-inch per hour per sq. ft. per degree F at a mean temperature of 75 degrees F with a minimum service temperature of 55 degrees F and a maximum service temperature of 1200 degrees F, with a melting point of 2000 degrees F and a flame spread rating of 5 and a smoke developed rating of 0 when tested in accordance with ASTM E84. Provide insulation that conforms to the following:~~

~~ASTM C356, C411, C518, C547, C585, E84, E136~~

~~D. Polyisocyanurate rigid insulation with a factory applied vapor barrier, with self-sealing laps an separate self-adhesive butt strips. Provide insulation with a maximum flame spread rating of 25 and a maximum smoke developed rating of 50 in accordance with ASTM E84 in thickness up through 1-1/2 inches. Minimum service temperature use: -60 degrees F and maximum temperature use: 300 degrees F. Provide insulation with a thermal conductivity ‘k’ of 0.19 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Minimum density of 2 lb/cu. ft. Polisocyanurate insulation in excess of 1-1/2 inch thickness will be permitted in Mechanical~~

~~Equipment Rooms not used as return air plenums and outdoor locations only. Provide insulation conforming to the following standards:~~

~~ASTM C177 or 518, C272, C335, C591, C1136, D2842, E84, E96.~~

~~E. Extruded foamed polystyrene thermal insulation with a factory applied vapor barrier, with self-sealing laps and separate self-adhesive butt strips. Minimum service temperature use: -60 degrees F and maximum temperature use: 165 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.26 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Extruded Foamed Polystyrene will be permitted in Mechanical Equipment Rooms not used as return air plenums and outdoor locations only. Provide insulation conforming to the following standards:~~

~~ASTM C177 or 518, C272, C335, C755, C1136, D2842, E96.~~

~~F. Phenolic foam rigid thermal insulation with a factory applied vapor barrier, with self-sealing laps and separate self-adhesive butt strips. Minimum service temperature of -60 degrees F and a maximum service temperature of 250 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.13 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Minimum density of 2.2 lb. cu/ ft. Provide insulation and jacketing conforming to the following standards:~~

~~ASTM C177 or C518, C273, C411, C1126, D696, D1622, D2842, E84, E96~~

~~G. Calcium silicate molded high temperature, block insulation, provided in half sections. Provide insulation with a maximum flame spread and smoke developed rating of 0 in accordance with ASTM E84, with a minimum service temperature of 200 degrees F and a maximum service temperature of 1200 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.36 Btu/hr/sq. ft./degree F/in. at 100 degrees F. Provide insulation that conforms to the following:~~

~~ASTM C 533, C795, E84, E136~~

~~H. Perlite rigid high temperature, block insulation, provided in half sections. Provide insulation with a maximum flame spread and smoke developed rating of 0 in accordance with ASTM E84, with a minimum service temperature of 200 degrees F and a maximum temperature of 1200 degrees F. Provide insulation with a thermal conductivity rating, 'k' of 0.44 Btu/hr/sq. ft./degree F/in. at 100 degrees F. Provide insulation that conforms to the following:~~

~~ASTM C177, C203, C209, C303, C356, E84~~

~~I.~~B. Pipe Insulation Minimum Thickness

1. Abbreviations

   DOT Design operating temperature - degrees F

   Nominal pipe size

   A - Run-outs up to NPS 2 (DN 50) - Note 1

   B - NPS 1 (DN 25) and less

   ~~C - NPS 1-1/4 to 2 (DN 32 to 50)~~

   ~~D - NPS 2-1/2 to 4 (DN 65 to 100)~~

   ~~E - NPS 5 and 6 (DN 125 and 150)~~

   ~~F - NPS 8 (DN 200) and up~~

2. Heating Systems: Heating Hot Water. Indoor: (glass fiber~~, phenolic foam (~~200 deg. F max~~.), calcium silicate, perlite, mineral wool, polyisocyanurate or cellular glass insulation)~~. ~~Outdoor: (cellular glass, phenolic, polyisocyanurate, or perlite insulation).~~

DOT	NPS					
	A	B	C	D	E	F
	English units		Thickness in inches			
Above 350	1.5	2.5	2.5	2.5	3.0	3.5
251-350	1.5	2.0	2.5	2.5	3.5	3.5
201-250	1.0	1.5	1.5	2.0	2.0	3.5
141-200	1.0	1.5	1.5	1.5	1.5	1.5

a. Insulation thicknesses are based on glass fiber insulation (k = 0.23). Adjust the thicknesses for insulations with other k factors to provide the equivalent insulating efficiency, based on the following formula:

Thickness of other insulation = (thickness of glass fiber x 'k' for other insulation) / 0.23

3. Ambient and Chilled Systems: Chilled Water, Glycol Heat Recovery, and Condenser Water. (polyisocyanurate, extruded polystyrene, or cellular glass insulation)

DOT	NPS				
A	B	C	D	E	F
English units		Thickness in inches			
40-105	0.5	0.5	0.5	1.0	1.0	1.0

a. Insulation thicknesses are based on polyisocyanurate insulation (k = 0.19). Adjust the thicknesses for insulations with other k factors to provide the equivalent insulating efficiency, based on the following formula:

Thickness of other insulation = (thickness of polyisocyanurate x 'k' for other insulation) / 0.19

J. For piping installed in outdoor locations, increase insulation thickness 1 inch. Note: 25/50 flame/smoke requirements not applicable.

Note 1: Run-outs to individual terminal units not exceeding 12 ft. in length.

2.4 HEATED EQUIPMENT INSULATION SCHEDULE

A. Glass fiber, rigid board insulation, non-combustible, with a thermal conductivity 'k' of 0.23 Btu/hr/sq. ft./degree F/in at 75 degrees F mean temperature with a maximum service temperature of 450 degrees F and a density of 3.0 lb/cu. ft. Provide insulation that conforms to the following standards:

ASTM C612, C795, NFPA 90A, 90B.

See Note 1

B. Cellular glass insulation consisting of inorganic, foamed or cellular glass, annealed, rigid hermetically sealed cells with an ASTM C921, Type 1, factory-applied, polymer-modified bituminous compound reinforced with a 4-mil, high density, cross laminate, polyethylene top film. Provide insulation with a thermal conductivity 'k' of 0.32 Btu/hr/sq. ft./degree F/in. at 75 degrees F

mean temperature and a maximum service temperature of 900 degrees F. Provide insulation and jacketing conforming to the following standards:

ASTM C177, C203, C240, C303, C518, C552, C623, E96, E228.

C. Mineral wool, jacketed, rigid board insulation, noncombustible, with a thermal conductivity 'k' of 0.24 Btu inch per hour per sq. ft. per degree F at mean temperature of 75 degrees F, with a maximum service temperature of 1200 degrees F, a melting point of 2000 degrees F, a flame spread rating of 5 and a smoke developed rating of 0 when tested in accordance with ASTM E84. Provide insulation that conforms to the following:

ASTM C356, C411, C518, E84, E136.

See Note 1

D. Polyisocyanurate rigid insulation with self-sealing laps an separate self-adhesive butt strips. Provide insulation with a maximum flame spread rating of 25 and a maximum smoke developed rating of 50 in accordance with ASTM E84 in thickness up through 1-1/2 inches. Maximum service temperature: 300 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.19 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Minimum density of 2 lb/cu. ft.. Polisocyanurate insulation in excess of 1-1/2 inch thickness will be permitted in Mechanical Equipment Rooms not used as return air plenums and outdoor locations only. Provide insulation conforming to the following standards:

ASTM C177 or 518, C272, C335, C591, C1136, D2842, E84, E96.

E. Phenolic foam rigid insulation with a factory applied vapor barrier. Maximum service temperature: 250 degrees F. Provide insulation with a thermal conductivity 'k' 0.13 BTU/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Minimum density: 2.2 lb/cu. ft. Provide insulation and jacketing conforming to the following:

ASTM C177 or C518, C273, C411, C1126, D696, D1622, D2482, E84, E96

F. Calcium silicate molded high temperature, block insulation, provided in half sections. Provide insulation with a maximum flame spread and smoke developed rating of 0 in accordance with ASTM E84. Maximum service temperature: 1200 degrees F. Provide insulation with a thermal conductivity, k: of 0.36 Btu/hr/sq. ft/degree F/in. at 100 degrees F. Provide insulation that conforms to the following:

ASTM C 533, C795, E84, E136

See Note 1

G. Perlite rigid high temperature, block insulation, provided in half sections. Provide insulation with a maximum flame spread and smoke developed rating of 0 in accordance with ASTM E84. Maximum service temperature: 1200 degrees F. Provide insulation with a thermal conductivity rating, 'k' of 0.44 Btu/hr/sq. ft./degree F/in. at 100 degrees F. Provide insulation that conforms to the following:

ASTM C177, C203, C209, C303, C356, E84

H. Insulation thickness schedule

Service Temperature (Degrees F)	Thickness of Insulation (inches)
Up to 140	1

Service Temperature (Degrees F)	Thickness of Insulation (inches)
141 to 200	1-1/2
201 to 250	2-1/2
251 to 350	3-1/2
Above 350	4-1/2

I. Insulation Thickness Schedule

1. Insulation thicknesses are based on glass fiber insulation (k = 0.23). Adjust the thicknesses for insulations with other k factors to provide the equivalent insulating efficiency, based on the following formula:

Thickness of other insulation = (thickness of glass fiber x 'k' for other insulation) / 0.23

J. For equipment installed in outdoor locations, increase insulation thickness by 1 inch. Note: 25/50 flame/smoke requirements not applicable.

Note 1: Insulation for indoor applications only

2.5 AMBIENT AND CHILLED EQUIPMENT INSULATION SCHEDULE

A. Cellular glass insulation consisting of inorganic, foamed or cellular glass, annealed, rigid hermetically sealed cells with all joints butt and longitudinally sealed with an approved elastic joint sealer to provide a vapor barrier, or, apply ASJ, Dow "Saran 520" or VyTech "Atlas VRP" vapor barrier jacket with self-sealing laps and separate self-adhesive butt strips. Provide insulation with a thermal conductivity 'k' of 0.32 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature and a minimum service temperature of -60 degrees F. Provide insulation and jacketing conforming to the following standards:

ASTM C177, C203, C240, C303, C518, C552, C623, E96, E228.

B. Polyisocyanurate rigid insulation with a factory applied vapor barrier, such as Dow "Saran 520" or VyTech "Atlas VRP", with self-sealing laps an separate self-adhesive butt strips. Provide insulation with a maximum flame spread rating of 25 and a maximum smoke developed rating of 50 in accordance with ASTM E84 in thickness up through 1-1/2 inches. Minimum temperature use: -60 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.19 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Minimum density of 2 lb/cu. ft. Polyisocyanurate insulation in excess of 1-1/2-inch thickness will be permitted in Mechanical Equipment Rooms not used as return air plenums and outdoor locations only. Provide insulation conforming to the following standards:

ASTM C177 or 518, C272, C335, C591, C1136, D2842, E84, E96.

C. Extruded foamed polystyrene thermal insulation with a factory applied vapor barrier, such as Dow "Saran 520" or VyTech "Atlas VRP", with self-sealing laps and separate self-adhesive butt strips. Minimum temperature use: -60 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.028 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Extruded foamed polystyrene will be permitted in Mechanical Equipment Rooms not used as return air plenums and outdoor locations only. Provide insulation conforming to the following standards:

ASTM C177 or 518, C272, C335, C755, C1136, D2842, E96.

D. Insulation Thickness Schedule

1. Insulation minimum thickness: 1/2 inch based on phenolic foam (k = 0.13). Adjust the thicknesses for insulations with other k factors to provide the equivalent insulating efficiency, based on the following formula:

Thickness of other insulation = (thickness of phenolic foam x 'k' for other insulation) / 0.13

E. For equipment installed in outdoor locations, increase insulation thickness by one inch. Note: 25/50 flame/smoke requirements not applicable.

2.6 COLD EQUIPMENT INSULATION SCHEDULE

A. Cellular glass insulation with vapor barrier consisting of inorganic, foamed or cellular glass, annealed, rigid hermetically sealed cells with an ASTM C921, Type 1, factory-applied, polymer-modified bituminous compound reinforced with a 4-mil, high density, cross laminate, polyethylene top film. Provide insulation with a thermal conductivity 'k' of 0.32 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature with a minimum service temperature of -60 degrees F and a maximum service temperature of 900 degrees F. Provide insulation and jacketing conforming to the following standards:

ASTM C177, C203, C240, C303, C518, C552, C623, E96, E228.

B. Polyisocyanurate rigid insulation with a factory applied vapor barrier, with self-sealing laps an separate self-adhesive butt strips. Provide insulation with a maximum flame spread rating of 25 and a maximum smoke developed rating of 50 in accordance with ASTM E84 in thickness up through 1-1/2 inches. Minimum service temperature use: -60 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.19 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Minimum density of 2 lb/cu. ft. Polyisocyanurate insulation in excess of 1-1/2 inch thickness will be permitted in Mechanical Equipment Rooms not used as return air plenums and outdoor locations only. Provide insulation conforming to the following standards:

ASTM C177 or 518, C272, C335, C591, C1136, D2842, E84, E96.

C. Extruded foamed polystyrene thermal insulation with a factory applied vapor barrier, with self-sealing laps and separate self-adhesive butt strips. Minimum service temperature use: -60 degrees F. Provide insulation with a thermal conductivity, 'k' of 0.028 Btu/hr/sq. ft./degree F/in. at 75 degrees F mean temperature. Extruded foamed polystyrene will be permitted in Mechanical Equipment Rooms not used as return air plenums and outdoor locations only. Provide insulation conforming to the following standards:

ASTM C177 or 518, C272, C335, C755, C1136, D2842, E96.

D. Insulation Thickness Schedule

1. Insulation minimum thickness 1/2 inch for phenolic foam (k = 0.13). Adjust the thicknesses for insulations with other k factors to provide the equivalent insulating efficiency, based on the following formula:

Thickness of other insulation = (thickness of phenolic foam x 'k' for other insulation) / 0.13

E. For equipment installed in outdoor locations, increase insulation by 1 inch. Note: 25/50 flame/smoke requirements not applicable.

2.72.4 AIR HANDLING APPARATUS AND DUCTWORK INSULATION SCHEDULE

A. Exposed Locations

1. Glass fiber, rigid board insulation with a minimum service temperature use of 55 degrees F and a thermal conductivity 'k' of 0.23 Btu/hr./ sq. ft./(degree F/in at 75 degrees F mean temperature and a density of 3 lb./cu. ft. and a vapor barrier jacket consisting of Kraft paper

~~bonded to aluminum foil, reinforced with fiber glass yarn secured with UL listed pressure sensitive tape. Provide insulation conforming to the following standards:~~

~~ASTM C612, C795, C1136; NFPA 90A, 90B.~~

~~B.~~A. Concealed Locations

1. Glass fiber, flexible blanket insulation with a minimum service temperature use of 40 degrees F and a thermal conductivity 'k' of 0.27 Btu/hr/sq. ft./degree F/in at 75 degrees F mean temperature and a density of 1.0 lb/cu. ft. and a vapor barrier jacket of aluminum foil reinforced with fiberglass yarn and laminated to a fire-resistant Kraft, secured with UL listed pressure sensitive tape. Provide insulation conforming to the following standards:

   ASTM C1136, E84; NFPA 90A, 90B.

~~C.~~B. Insulation Thickness: 1-1/2 inch

~~D. For equipment and ductwork installed in outdoor locations, increase insulation thickness by 1 inch.~~

~~2.8~~2.5 INSULATION PROTECTION

A. Indoor Applications

1. Heated and cooled piping, equipment and ductwork.

   a. 0.020-inch-thick pvc on pipe covering and 0.030 inch-thick on ductwork and equipment. Provide pvc jacketing that has a flame spread rating of 25 or less and a smoke developed rating of 50 or less per ASTM E84.

2. Piping fittings, flanges, grooved pipe couplings, valves and pipe terminations.

   a. Molded fitting covers; Foster Products Corp. "Speedline 2"; Ceel-Co; Proto; or Johns Manville "Zeston 2000" pvc one-piece fitting covers, 0.02 inch-thick with a flame spread rating of 25 or less and a smoke developed rating of 50 or less per ASTM E84. On cold applications, use 0.030-inch pvc jacket and minimum 0.028-inch pvc covers.

~~B. Outdoor Applications~~

~~1. 0.016 inch smooth aluminum with factory applied moisture barrier liner.~~

PART 3 - EXECUTION

3.1 GENERAL APPLICATION REQUIREMENTS

A. Prior to the installation of insulating material, verify its thickness in accordance with the operating temperature and diameter of pipe or equipment. Should there be any discrepancies, notify the Architect and request resolution of the conflict; do not establish a new thickness or select different material without written approval.

B. Protect insulating materials from moisture and weather before and during installation.

C. Conduct required tests on piping, equipment and ductwork, and make correction, if required, prior to the application of insulation.

D. Install insulation, adhesives, coatings, mastics, sealants and tapes, only by experienced pipe coverers, in compliance with MICA standards and manufacturer's recommendations, including all safety requirements.

E. Maximum thickness of a single layer of insulation: 2-1/2 inches. Minimum thickness of each layer of multi-layer pipe covering: 1 inch.

F. Fabricate pipe covering and curved shapes in accordance with ASTM C450 and C585 with a minimum number of joints.

G. When building structures or equipment interfere with the insulation, coordinate installation with other trades.

H. Protect work of other trades from debris caused by the insulation work. Remove debris daily.

I. Provide removable sections of insulation or insulation boxes at all points where access is required. Assemble sections and boxes and install so disassembly, removal, and replacement will not damage the insulation.

J. Clean surfaces to be insulated, and make dry and free of loose scale, rust, dirt, oil and water before insulation, adhesives or mastics are applied.

K. Install insulation smooth and clean. Make joints tight and finished smooth. Do not use cracked, chipped, or torn insulation sections in the Work.

L. Provide thickness of the insulation the minimum specified or shown.

M. Make joints tight with insulation lengths and segments tightly butted against each other. Where lengths or segments are cut, make cuts smooth and square and without breakage of end surfaces.

N. Fit insulation tightly against surface to which it is applied.

O. Do not apply sealant or cement until previous applications of adhesives and cement have thoroughly dried.

~~P. Provide pre-molded pipe insulation with extended leg when used on pipes heat-traced with piping or cable.~~

~~Q. On heat-traced piping NPS ½ to 1-1/4, increase pipe insulation by one pipe size.~~

~~R. Above non-plenum ceilings, extend duct insulation on air conditioning supply air systems up to and around the supply air diffuser body.~~

~~S.~~P. Interrupt insulation at ductwork fire dampers in rated walls and floors.

~~T.~~Q. Restore existing insulation and surface finishes disturbed or damaged during the course of the work to original condition.

~~U.~~R. Provide insulation jackets as specified.

~~V.~~S. Provide insulated surfaces ready to receive a final coat of paint without the necessity of sizing or priming.

3.2 PIPING SYSTEMS APPLICATIONS

A. Insulate piping up through NPS 16 with two-piece, sectional pipe insulation~~; insulate piping larger than NPS 16 with sectional pipe covering or prefabricated curved sidewall segments~~. Trim all insulation segments and butt tightly to each other to eliminate voids, gaps or open joints; do not use joint sealer to fill these imperfections. Rub insulation ends against each other to achieve a tight fit prior to the application of joint sealer.

B. Install multiple layers of insulation so the butt and longitudinal joints of one layer do not coincide with those of any other layer. Stagger the outer joints by half sections over the inner joints with a minimum overlap of 18 inches.

C. On all indoor and outdoor applications, on hot piping systems, apply a vapor sealing joint sealer, 1/16-inch-thick to all butt and longitudinal joints of the outer layer of multi-layered installations and to all circumferential and longitudinal joints of single layer installations. Apply joint sealer so as to completely fill the thickness of the joints. Do not bond layers of insulation to each other; avoid applying excessive sealer in the joints and do not feather edge.

~~D. On all indoor and outdoor applications, on chilled, ambient and cold piping systems, apply a vapor sealing joint sealer, in full bed coverage (not a bead), for sealing all joints of insulation and pvc slip joints of the vapor barrier type, moisture and water resistant, 97 percent solids by weight, non-hardening and flexible with a service temperature range from -50 degrees F to 200 degrees F; Childers "CP-76", Foster "44" or "95-50" or as approved.~~

~~E.~~D. Fasten insulation circumferentially with 3/4-inch-wide tape, 2 inches from each end and in the middle of each pipe section and a minimum of two tapes per each section of equipment insulation. ~~Employ bands in lieu of tape on all piping above NPS 16 and an all curved wall sections where tape does not close the insulation joints tightly.~~ Apply tape at least 50 percent on itself. Do not tighten tape or bands so as to crush or crack the insulation; replace any broken insulation. Fasten the outer layer or single layer of equipment insulation with 1/2-inch, type 304 stainless steel bands on 12-inch centers.

~~F. Provide rigid cellular insulation fittings for flanges, valves including bonnet flanges, elbows, tees and other such fittings on both cold and hot systems, of pre-fabricated two-piece fly-cut or routed or two-piece mitered design (urethane spray foam fill is not acceptable) fabricated in accordance with ASTM C450 and ASTM C585. Allow bolt length plus 1 inch from flange for bolt removal. Provide insulation on flanges with overlap of the adjacent pipe covering by 2 inches and pack the void space with insulation and finish with molded fitting covers. Cut back insulation at valve packing glands and fill the space between the insulation and valve body with joint sealer with termination sealed with vapor barrier mastic.~~

~~G. On chilled, ambient and cold piping systems, provide a vapor barrier mastic, compatible with the insulation material, to seal the insulation on all fittings, valves, flanges including bonnet flanges, elbows, tees and other such fittings prior to the application of outer covering, that is water based and will remain flexible at the ambient temperature; Foster "30-80", Viamsco "Vapor-Block", Childers "Chil-Perm # CP-35" or as approved. Apply mastic on two coats with reinforcing fabric consisting of 6 x 6 glass fiber reinforcing mesh; Childers "Chil Glas #5" or Pittsburgh Corning "PC-79" fabric with 5 x 5 mesh or as approved.~~

~~H.~~E. Carry the vapor barrier mastic from the outer surface of the insulation to the uninsulated metal parts of the chilled and cold piping system to provide a continuous vapor seal at all terminations, nozzles, caps, etc. Extend vapor barrier on attachments, such as hangers and supports that are in direct contact with the cold surface, an additional 6 inches over the uninsulated surface. Install the reinforcing cloth so as to be completely covered with the mastic and ensure that there are no cracks, holes, thin spots or open joints in the vapor barrier. Allow the vapor barrier to dry per manufacturer's instructions before application of jacketing.

~~I.~~F. Check the vapor barrier for final dry thickness, continuity, cracks, thin spots, pinholes, etc. Repair unsatisfactory areas.

~~J. Seal openings on chilled, ambient and cold piping through insulation vapor tight by applying joint sealer between the protrusion and insulation.~~

~~K. On piping NPS 2-1/2 and larger, provide insulation support rings in each layer on vertical piping for each run over 21 feet and provide a contraction/expansion joint immediately below each support ring. Provide contraction/expansion joints in each layer of horizontal piping located midway between pipe supports and other protrusions through the insulation systems. Install~~

contraction/expansion joints comprised of a 1-inch space between insulation segments, filled in with 1-lb/cu.ft. density 3-inch long fiberglass blanket compacted to 1-inch in length. Provide contraction/expansion joints in both single and multiple layer applications with a 12-inch long additional layer of equivalent thickness insulation installed as an outer cover over the contraction/expansion joint. On chilled and cold piping, maintain vapor barriers continuous over contraction/expansion joints by stepping up and then down back to the pipe insulation.

L. On all chilled, ambient and cold piping provide vapor stops at all pipe supports and all changes in configuration such as elbows, flanges, insulation terminations and at all locations on piping requiring maintenance including instrumentation connections. Provide vapor stops consisting of reinforced vapor barrier mastic, and after drying, install adjacent segment of insulation using joint sealer.

M. 360-degree, high density, pre-insulated, pipe supports employing 360-degree shields are provided on insulated piping NPS 2-1/2 and larger under Division 23 sections of the Specifications. On chilled and cold piping, abut the pipe insulation at these supports employing a vapor stop and reinforced vapor barrier mastic overlapped circumferential seal and onto the pipe surfaces.

N. Provide fabricated insulation for chilled, ambient and cold piping with a factory applied integral vapor barrier jacket: ASJ, Dow "Saran 560, "Alaflex Style 13 MAM" or Polyguard "Insulwrap 30". Provide the vapor barrier jacket wrinkle free, covering all outer surfaces of the insulation sealed longitudinally by an integral self sealing lap (SSL) and a 3-in-wide sealing tape for butt joints. Use of staples for securing jacket laps is prohibited. Install longitudinal laps at ten o'clock or two o'clock.

O. Cover and completely seal all chilled, ambient and cold piping with a vapor barrier, continuous on all surfaces, prior to the application of jacketing. Seal weld all circumferential and longitudinal laps with pvc solvent welding adhesive. Install 1-1/2-inch-wide self-sealing lap tape on the joints of the jacket in addition to the adhesive. Apply laps with a minimum of 2 inches on both the circumferential and longitudinal joints.

3.3 HEATED EQUIPMENT APPLICATION

A. Round Equipment

1. Cut or miter insulation where necessary to fit the shape and contour of the equipment and band in place with 3/4-inch x 0.015-inch-thick stainless steel bands on 18-inch centers. Point up joints with insulating cement.

2. For domed ends or vessel heads, install factory-molded, precurved pieces to exactly conform to the double radius curvature of the vessel top in accordance with ASTM C450.

B. Flat or Irregular Equipment

1. Cut insulation to fit the shape and contour of the equipment. Pack voids between equipment surface and insulation with light density glass fiber. Impale glass fiber insulation over welded pins on 12-inch centers and secure in place with speed washers.

C. Prime Coat

1. After insulation cement has dried, apply a primer coat of Childers Products "CP-50" diluted 50 percent with water and allow to dry completely before applying the finish coats.

D. Finish Coat

1. Apply mastic finish coat of Foster "35-00" or Childers Products "Vi-Cryl CP-10/11", in two coats. Apply the first or tack coat at a rate of two gallons per 100 sq. ft., and, while still wet, embed the layer of canvas with fabric seams overlapped a minimum of 2 inches. Within one

hour after applying tack coat, apply a finish coat - coverage four gallons per 100 sq. ft. - fully covering cloth fabric and apply to a minimum dry film thickness of 1/16 inch. Provide the finish coat with a smooth, even finish with no voids or holidays.

3.4 AMBIENT AND CHILLED AND COOLED EQUIPMENT APPLICATION

A. For Insulation (on ambient and chilled equipment only)

1. Apply sheet insulation over all surfaces without stretching.
2. Cover all devices on tanks and heat exchangers with mitered sections of insulation so as to facilitate their servicing and removal without disturbing the equipment insulation.
3. Install insulation on pumps so that the pump casing can be separated without damaging the insulation on the casing body.
4. If sheet insulation is not provided with a factory-applied contact adhesive, then apply sheet insulation with the smooth or skin side out. Adhere insulation with complete coverage of adhesive. Apply a thin but adequate coat on both surfaces to be joined. Allow the adhesive films to air-dry until dry to touch but tacky under slight pressure before joining surfaces. Avoid open time in excess of 20 minutes. Apply moderate pressure to entire areas, insuring complete contact. Since adhesive is an instant-bonding type, position surfaces accurately as contact is made. Apply adhesive at temperatures above 40 degrees F. Do not apply to heated surfaces or to insulation over heated surfaces. Allow adhesive joints applied with full adhesive bonding to dry for 7 days before applying solvent base finishes.
5. Ensure that metal surface is clean and dry and free of all dirt, scale, loose paint, plaster, oil, etc.
6. If the metal surface has been primed, apply adhesive with a brush to a test area approximately 2 square feet to determine whether the solvent in the adhesive will loosen or lift the primer. If there is any indication of loosening or lifting the primer, do not apply insulation until primer has been removed and re-applied properly.
7. Do not apply insulation over asphaltic surfaces.
8. Provide adhesives that are compatible with the insulation employed.
9. Apply adhesive to the surface to be insulated with brush or short-nap paint roller, covering enough area to receive one sheet of insulation.
10. Apply adhesive to the back of the sheet with brush or short-nap paint roller, leaving 1/2-inch-wide, uncoated border around the perimeter of the sheet.
11. Allow the adhesive to dry to the touch before bringing the two surfaces into contact.
12. Position the sheet in such manner that it overlaps the edges of the previously installed sheet or sheets by 1/8 inch. While held in this position, spot-adhere the center of the sheet. Compress the butt edges into place to achieve a tight joint. Bond the remainder of the sheet by pressing firmly into place.
13. Spread the joint and, by means of a small brush, apply adhesive to both butt edges - do not fill joint with adhesive. No open time is required for this adhesive application; however, align the butt edges for good appearance.
14. Stagger the vertical joints where sheet insulation is applied to vertical tanks. In the case of horizontal tanks, stagger the horizontal joints.
15. If insulation with a self-adhering back is employed, wipe all surfaces with an alcohol soaked damp rag before applying sheet.

B. For Other Insulations

1. Provide vessel head segments curved, double radius contoured for the exact curvature of the vessel head. Provide curved sidewall segments for vessels and equipment fabricated per ASTM C450 to fit the contour of the surface in equal pieces to go around the vessel wit the minimum number of through joints.

2. Provide a water based vapor barrier mastic, that is compatible with the insulation material and that remains flexible at the environmental temperature, to seal all insulation joints on the equipment prior to the application of the outer covering; Foster "30-80" or "30-90", Viamsco "Vapor-Block #749" or Childers "Chil-Perm #CP-35", or as approved.

3. Provide a membrane for reinforcement for the vapor barrier mastic that is 6 X 6 glass fiber reinforcing mesh; Childers "Chil Glas #5", Pittsburgh Corning "PC-79 Fabric" with 5 X 5 mesh, or as approved.

4. Provide the vessels, tank ends, irregular surfaces, contraction/expansion joints, valves and fittings vapor sealed with the reinforced vapor barrier mastic applied to a minimum total dry (cured) film thickness of 0.038 inch or as recommended by the mastic manufacturer. Evenly apply the first layer of mastic by suitable means as a tack coat over the insulation or vapor barrier with an approximate 0.032 inch wet film thickness. Then apply reinforcing cloth, stretched tight, embedded into the still tacky first layer of mastic with a 3 inch overlap. Apply the second layer of mastic with 0.032 inch wet film thickness.

5. Carry the vapor barrier mastic from the outer surface of the insulation to the uninsulated metal parts of the vessel to provide a continuous vapor seal at all terminations, projections, nozzles, caps, etc. Extend vapor barrier on attachments, such as hangers and supports, an additional 6 inches over the uninsulated surface. Install the reinforcing cloth so as to be completely covered with mastic and ensure that there are no cracks, holes, thin spots or open joints in the vapor barrier. Allow the vapor barrier to dry per manufacturer's instructions before the application of any jacketing.

6. Check the vapor barrier for final dry thickness, continuity, cracks, thin spots, pinholes, etc. Repair unsatisfactory areas.

7. Cover and completely seal all equipment with a vapor barrier, continuous on all surfaces, prior to the application of the jacketing. Seal weld all joints with pvc solvent welding adhesive. Follow manufacturer's recommendations in handling and application of the adhesive. Install 1-1/2 inch wide self-sealing lap tape on the joints of the jacket in addition to the adhesive. Apply tape with a minimum overlap of 2 inches on the joints.

3.53.3 AIR HANDLING APPARATUS AND DUCTWORK INSULATION APPLICATION

A. Rigid Board Insulation

1. Impale rigid board insulation over mechanical fasteners on 12 inch to 18 inch centers. Use a minimum of two rows of fasteners per side. Secure insulation with speed fastener or clip, and point up fasteners, joints and breaks with vapor barrier coating of Foster "30-35", Childers Products "Encacel V", or as approved.

2. Paste laps of covering in place with adhesive, such as Foster "85-20" or Childers Products "CP-82". Where insulation has been trimmed flush, seal joints with 4 inch wide butt strips of 2 mil foil facing material or as recommended by the manufacturer of the insulation. Tape pin penetrations, punctures and joints. Tightly seal strap and angle hanger penetrations.

B.A. Flexible Insulation

1. Wrap flexible insulation around ducts using the lap seal butt-joint method with factory-applied vapor-barrier tape. Stapling is not permitted.

2. On ducts 24 inches or more in width, use mechanical fasteners on the bottom of the duct to guard against possible sagging. Provide mechanical fasteners and spacing as specified for rigid board insulation.

3. Tape pin penetrations, punctures and joints. Tightly seal strap and angle hanger penetrations.

~~3.6~~3.4 INSULATION PROTECTION APPLICATION

A. Indoor Applications: piping, fittings, equipment and ductwork exposed below 10 feet above a floor or other walking surface.

1. Heated Piping and Equipment

a. Ensure that no gaps exist in the insulation that would expose the pvc jacket to excessively high temperatures. Do not apply pvc jacketing adjacent to hot surfaces.

b. Do not install the jacketing system with an ambient temperature under 35 degrees F.

c. Install 0.020-inch –thick pvc for pipe and fittings and 0.030-inch –thick pvc for equipment with matching one piece pvc fitting covers. Provide the jacketing cut and precurled, with double faced self-sealing longitudinal lap joint tape. Overlap all pvc jacketing seams a minimum of 2 inches.

d. Where the pvc jacketing is field cut, secure the longitudinal overlap with white painted stainless steel tack fasteners on 9-inch centers

e. Cover the fiberglass wrapped fittings with the pvc fitting covers and secure the fitting covers with 0.010-inch-thick pvc tape.

f. Seal all end terminations with pvc end caps and seal the end caps to the insulating jacketing and the bare pipe using only Dow “791” sealer, troweled or brushed to a minimum of 1/16 inch-thick coating, extending the coating 2 inches over the bare insulation, the bare pipe and under the adjacent jacketing.

g. Where the operating temperature exceeds 180 degrees F, seal the end terminations with a brush coat of silicone sealant.

h. Install pvc valve and flange covers in the same manner as the pipe jacketing, using extra long pvc covers to allow for bolt removal clearance.

~~2. Ambient and Chilled and Cold Piping, Equipment and Ductwork~~

~~a. Ensure that the insulation vapor barrier is properly sealed in accordance with the manufacturer's recommendations and the surface of the vapor barrier is perfectly dry before applying the pvc jacket.~~

~~b. Do not install jacketing system with an ambient temperature under 35 degrees F.~~

~~c. Install the pvc jacketing with matching one-piece pvc fitting covers. Provide the jacketing cut and precurled with longitudinal self-sealing lap tape over the properly sealed vapor barrier jacket. Overlap the circumferential seams by 2 inches. Paint all seam lap edges with pvc adhesive. Temporarily secure jacket with tape or elastic bands until the adhesive has dried.~~

~~d. Install pvc valve and flange covers in the same manner as the pipe jacketing, properly sealing around valve packing glands and stems, using extra long pvc covers to allow~~

for bolt removal. Seal the insulation on all fittings, elbows, couplings, flanges, valve bodies, etc. with Dow "Saran 520" or mastic/ fabric/mastic application.

B. Outdoor Applications: all outdoor insulated piping, fittings, and equipment.

1. General

a. Install metal jacket weatherproofing over the outer surfaces of all insulation work on all piping, ductwork and equipment located outdoors. Fabricate all metal jacketing of aluminum.

b. Install metal jacketing as soon as possible after the insulation work has been completed. At the end of the day apply the metal jacketing to all insulation materials applied on that day. Temporarily protect any exposed insulation with a combination moisture and/or UV barrier such as black polyethylene film, sealed to the pipe, duct or equipment.

c. Do not apply mastics when the ambient temperature is, or is expected to be in the next 24 hours, below 340 degrees F unless specifically approved for that use by the manufacturer.

d. Cut all openings in the metal jacketing for nozzles, brackets, protrusions, etc. as close as possible to achieve a tight fit. Use silicone or butyl based caulking compounds to seal all projections and penetrations.

2. Piping

a. Provide a minimum of 2 inch overlap on all circumferential and longitudinal joints. Locate the longitudinal lap on horizontal piping alternatively at either the ten o'clock or two o'clock position to shed rainwater. Support metal jacketing on vertical piping by means "S" clips made from stainless steel metal bands.

b. Provide preformed RPR "Insul-Mate" metal elbows, Childers "ELL-Jac" or "Univers-Ells" for fittings on piping up to NPS 12 and metal gore elbows on piping above NPS 12. Provide smooth metal jacketing over flanges and flanged fittings. Use stainless steel bands for securing metal jacketing on preformed and gored elbow covers. Provide metal jacketing with raised bead for proper closing of gores. Wherever possible, avoid using screws, pop rivets, etc; however where they must be used to secure irregular shapes, drill all holes before the metal jacketing is put in place over the insulation. Tape a 3 inch wide by 0.020 inch aluminum strip over the insulation under the seam of the metal jacketing.

3. Ductwork and Equipment

a. Apply metal jacketing for horizontal and vertical ductwork and equipment surfaces with 3 inch joint laps.

b. Fabricate metal jacketing for equipment vessel heads of a one piece dish or conical sections fitted to the insulation. Install head covers to overlap the shell jackets by 4 inches and fasten by means of 1/2 inch x 0.020 inch stainless steel band, one for every gore. Install an additional band, 4 inches wide and secure with stainless steel bands.

c. Secure metal jacketing on horizontal and vertical ductwork and equipment with 1/2 inch x 0.020 inch stainless steel bands spaced on 12 inch centers. Wherever possible, avoid using screws, pop rivets, etc.; however where they must be used to secure irregular shapes, drill all holes before the metal jacketing is placed over the

~~insulation. Support metal jacketing on vertical equipment by means of "S" clips on 12 inch centers.~~

END OF SECTION 230700

SECTION 230900
INSTRUMENTATION AND CONTROL 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 SUMMARY

A. This Section includes:

1. Extent of control systems work required by this Section is indicated on drawings and schedules, and by requirements of this Section.

2. Control sequences are specified on the drawings

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.4 REFERENCES

A. Applicable Standards:

1. National Electrical Manufacturers' Association (NEMA)

2. National Fire Protection Association (NFPA)

a. 70 - National Electrical Code (NEC)

b. 90A - Air Conditioning and Ventilating Systems

3. Underwriters Laboratories (UL)

1.5 SUBMITTALS

A. General: Submit the following in accordance with Division 23 sections of the Specifications.

B. Product Data:

1. Submit manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. All submittals must be provided in both hard copy and digital (PDF) format. Scanned copies of documents must be provided if other digital copy not available.

2. Also include installation and start-up instructions.

C. Shop Drawings:

1. Use NREL’s master set of control drawings as basis for shop drawings.

2. Submit shop drawings for each control system containing the following information:

3. Schematic flow diagram of system showing boilers, ~~chillers,~~ pumps, terminal box and other coils, valves, and control devices~~. The NREL control diagrams are available on AutoCAD 2014 and may be used as the basis for the flow diagram.~~

4. Label each control device with setting or adjustable range of control and device name.

5. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

6. Include verbal description of sequence of operation and software descriptions. Submit flow charts for approval with sequence of operation.

7. Plan drawings of panel locations.

8. Input/output (I/O) summary forms that include:

   a. Point list including point descriptions.

   b. Hardware list for each binary and analog function.

   c. Alarm limit and failure mode lists.

   d. Application program list for each piece of equipment.

D. Maintenance Data:

1. Submit maintenance instructions and spare parts lists for each type of control device.

2. Include that type data, product data, and shop drawings in Operating and Maintenance Manual in accordance with requirements of Division 23 sections of the Specifications. These must be provided in PDF format in addition to hard copy.

3. Submit as built drawings and as built AutoCAD 2014 files for all drawings. Verify most current AutoCAD version being utilized by NREL.

4. All drawings must be fully integrated into the NREL master set of existing control drawings. This includes using NREL's standard border for drawings, and numbering the new drawings to match existing master drawing set, as well as updating any impacted existing drawings. A complete single set of control drawings must be maintained for each building.

1.6 QUALITY ASSURANCE

A. Manufacturer's Qualification: Firms regularly engaged in manufacture of control equipment, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

B. Installer's Qualifications: Firms specializing and experienced in control system installations for not less than five years.

C. Codes and Standards

1. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled and comply with NEMA standards.

2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for control systems.

3. NFPA Compliance: Comply with NFPA 90A where applicable to controls and control sequences.

1.7 DELIVERY, STORAGE, AND PROTECTION

A. Provide factory-shipping cartons for each piece of equipment and control device.

B. Maintain cartons while shipping, storing, and handling as required to prevent equipment damage and to eliminate dirt and moisture from equipment.

C. Store equipment and materials inside and protect from weather.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide control systems from:

1. Delta Controls

   c/o Setpoint Systems Corporation

   8167 SouthPark Circle

   Littleton, CO 80120

2.2 MATERIALS

A. General:

~~1. Furnish and install a complete control system consisting of an Energy Monitoring and Control System (EMCS).~~

~~a. The control system shall be complete in all respects including labor, materials, equipment, and services necessary, and shall be installed by personnel regularly employed by the manufacturer.~~

~~2.~~1. All automation and control components shall be integrated into a distributed network system communicating over a nonproprietary local area network.

a. This system shall consist of field Stand-alone Direct Digital Controllers (DDC), Smart Local DDCs, and multiple Personal Computer (PC) based operator workstations. Firmware and software shall match existing NREL system unless approved by NREL.

b. The communication between major system components shall be Ethernet. Any communication lines that are between building, exposed outdoors or underground shall be fiber optics with conversion to Ethernet inside the buildings.

~~3.~~2. The EMCS shall consist of the following items:

a. Stand-alone DDC panels.

b. Stand-alone Smart Local Controllers (SLC).

~~c. Personal Computer (PC) Operator Workstations supplied by contractor for each building. If work is in an existing building with an existing workstation, then a new one does not need to be provided. All new buildings require new workstations.~~

~~4.~~3. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection.

a. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

~~5.~~4. Stand-alone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC panel or combination of panels on the network without dependence upon a central processing device. Stand-alone DDC panels shall also be able to send alarm reports to operator workstations without dependence upon a central processing device polling them.

B. Hardware, Stand-Alone DDC Panels:

1. General:

a. Stand-alone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors.

b. A sufficient number of controllers shall be supplied to meet the requirements of the sequence of operation.

2. Communication Ports:

a. Stand-alone DDC panels shall provide at least one Ethernet data communication port.

b. For simultaneous operation of multiple operator I/O devices, stand-alone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

3. Power Failure Restart:

a. In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software.

b. Nonvolatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 48 hours.

c. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

d. All devices including control panels, network hubs, or other devices required for the operation of the DDC system, must be on emergency power where available.

C. Hardware - Smart Local Controllers:

1. Each Stand-alone DDC Controller shall be able to extend its performance and capacity through the use of remote Smart Local Controllers (SLC). The SLC shall be application specific, dedicated DDC controllers.

2. Each SLC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each SLC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

3. Each SLC shall have sufficient memory to support its own operating system and data bases, including:

a. Weekly scheduling.

b. Control Processes.

c. Energy Management Applications.

4. Power Failure Protection: All system set points, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

5. HVAC Applications:

a. Each SLC shall support the following library of control strategies to address the requirements of the sequences described in the Sequence of Operation.

b. Occupancy-Based Standby/Comfort Mode Control:

1) Each SLC shall have a provision for occupancy sensing overrides.

2) Based upon the contact status of either a manual wall switch or an occupancy-sensing device, the SLC shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

c. VAV Terminal Unit Controllers: VAV Terminal Unit Controllers shall support, but not be limited to, the control of the following configurations of VAV boxes to address requirements as described in the Sequence of Operation and for future expansion:

1) Single Duct Only (Cooling Only, or Cooling with Reheat)

~~2) Fan Powered (Parallel Fan, Series Fan)~~

~~3) Dual Duct (Constant Volume, Variable Volume)~~

d. VAV Terminal Unit Controllers shall support the following types of point inputs and outputs:

1) Proportional Cooling Outputs

2) Box ~~and Baseboard~~ Heating Outputs (Proportional, or 1 to 3 Stages)

~~3) Fan Control Output (On/Off Logic, or Proportional Series Fan Logic)~~

6. Lighting Applications:

a. Each Stand-alone DDC Controller shall be able to extend its performance and capacity through the use of remote Smart Local Controllers (SLC) dedicated to controlling lighting. Lighting Control SLC shall provide stand-alone remote control of building lighting circuits, including weekly and holiday time programming, local overrides, and local status indication.

b. Occupancy-Based Lighting Control: Each lighting circuit shall have an associated binary override input for monitoring motion detectors, wall switches, photocells, or similar devices. Based upon the contact status of an occupancy-sensing device, the Lighting Controller shall automatically override normal scheduled control to reduce electricity consumption while satisfying occupant lighting requirements.

D. Sensors and Controllers:

1. Input: Provide devices as required to perform the functions described in the sequence of operation.

a. Temperature:

1) Temperature sensors and transmitters shall be as described below or as required for the application.

a) Sensors and transmitters shall be capable of being calibrated.

2) Space Temperature Transmitter:

a) Transmitter shall contain a Resistance Temperature Detector (RTD) sensing element to monitor room air temperatures in the range of 30°F to 90°F, unless indicated otherwise.

b) The assembly shall be installed within a ventilated enclosure suitable for wall mounting.

c) Transmitter shall be factory calibrated to an accuracy of ±1%.

~~3) Duct Averaging Type Temperature Transmitter:~~

~~a) Transmitter shall be a general purpose RTD sensing element, moisture resistant transmitter for indoor or outdoor mounting, or mounting into a duct.~~

~~b) The operating range shall be as indicated with an accuracy of ±1% over the full range.~~

~~4) Pipe Temperature Transmitter:~~

~~a) Transmitter shall contain an RTD sensing element to monitor water temperature.~~

~~b) The Contractor shall provide stainless steel wells of sufficient size for the pipe to be installed.~~

~~c) Transmitter shall be factory calibrated to an accuracy of ±1%.~~

~~b. Humidity:~~

~~1) Humidity sensors and transmitters shall be as described below or as required for the application.~~

~~2) Sensors and transmitters shall be capable of being calibrated.~~

~~a) Space Humidity Transmitter: Transmitter shall be capable of providing continuous measurement of percent relative humidity (RH) with an accuracy of ±3% over the range of 10 to 60% RH.~~

~~3) Duct Humidity Transmitter: Transmitter shall be capable of providing continuous measurement of percent relative humidity with an accuracy of ±4% over the range of 10 to 80% RH.~~

~~4) Outside Air Humidity Transmitter: Transmitter shall be capable of providing continuous measurement of percent relative humidity with an accuracy of ±2% over the range 20 to 90% RH. Transmitter shall have outside weather enclosure.~~

~~c.~~b. Pressure:

1) Pressure sensors, transmitters and switches shall be as described below or as required for the application.

2) Sensors and transmitters shall be capable of being calibrated.

a) Differential Pressure Transmitter: Transmitter shall provide a proportional signal with an accuracy of ±2% over the full range.

3) Differential Pressure Switch:

a) Switch shall be for liquid or vapor service.

b) Switch shall have a single-pole, single-throw (SPST) contact, adjustable dead band, brass bellows, UL rated 6 amperes at 120V 100 psig design, and with automatic reset.

c) Each switch shall be provided with isolation and drain valves.

~~d. Low Limit Thermostats:~~

~~1) Low limit thermostats shall be of automatic or manual reset type, with set point adjustment.~~

~~2) The sensing element shall be 20-foot minimum and shall be installed completely across the coil.~~

~~3) When any 1-foot of the element senses a temperature as low as the set point, the thermostat contacts shall open.~~

~~4) The thermostats shall contain double pole switches for simultaneous remote alarms.~~

~~e. Flow Switches:~~

~~1) Switches shall have a single-pole, single-throw (SPST) or double-pole, double-throw (DPDT) contact, adjustable dead band; UL rated 6 amperes at 120V.~~

~~2) Switch actuation shall be adjustable over the operating flow range.~~

~~f. Watt-Hour Transducers: Selected as required for application.~~

~~g. Voltage-to-Digital Alarm Relays: Relays shall be provided to monitor status of equipment safeties and overloads, sized and connected to not impede the function of the monitored contacts.~~

~~h.~~c. Current Sensing Relays: Relays shall be provided to monitor status of motor loads. Switch shall have adjustable set point.

~~i.~~d. Current Transformers (CT):

1) CTs with output scalable to current draw may be used in place of current sensing relays to monitor status of motors.

2) CTs shall be used if called out on drawings.

E. Software - Automatic Control:

1. General:

a. All necessary software to form a complete operating system as described in this specification shall be provided.

b. The software programs shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher-level computer for execution.

2. Run Time Totalization: Stand-alone DDC panels shall be programmed to accumulate and store run time hours for binary input and output points as identified in the sequence.

3. Analog/Pulse/or Event Totalization: Stand-alone DDC panels shall automatically sample, calculate and store consumption totals, or count events, on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points, or binary input points.

4. Dynamic Color Graphic Displays: Color graphic system schematics for each mechanical system, including air handling systems, chilled water systems, hot water systems and other mechanical systems along with floorplans shall be provided.
    a. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
    b. Peer-to-Peer Displays: Global temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

F. Documentation:
1. General: Provide reference material that contains an overview of the system, organization, terminology, abbreviations, symbols and job specific information as described below.
    a. Documentation shall also include an Input/Output summary table and plans showing equipment locations.
    b. All manuals shall be updated to reflect as built configuration after final acceptance and shall be provided in three-ring hard cover bindings.
2. Hardware: Provide the following documentation as a minimum on all hardware.
    a. Product catalog cuts and descriptions.
    b. Installation, mounting, connection, set-up, checkout, and tuning instructions.
    c. Maintenance procedures and spare parts list for all hardware.
3. Software: Provide the following documentation as a minimum on all software.
    a. Description of control logic including sequences.
    b. Lists of all set points, alarm points, and message conditions.
    c. Hard copy of graphics.

G. Materials and Equipment:
1. General:
    a. Provide electric control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, sensors, controllers, and other components as required for complete installation interfacing with DDC control system.
    b. Provide electric control systems with the following functional and construction features.
2. Control Valves:
    a. Provide factory fabricated electric control valves of type, body material, and pressure class indicated.
    b. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system.
    c. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve.

d. Except as otherwise indicated, provide valves which mate and match material of connecting piping.

e. Equip control valves with control valve motor actuators, with proper shutoff rating for each individual application.

f. Water Service Valves: Equal percentage characteristics with rangeability of 50 to 1, and maximum full flow pressure drop of 5 psig.

g. Single Seated Valves: Cage type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.

h. Double Seated Valves: Balanced plug type, with cage type trim providing seating and guiding surfaces on "top and bottom" guided plugs.

i. Valve Trim and Stems: Polished stainless steel.

j. Packing: Spring-loaded Teflon, self-adjusting.

k. Terminal Unit Control Valves:

1) Provide control valves for control of terminal units including, but not necessarily limited to, convectors, finned tube radiation, and fan-coil units. ~~that are of integral motor type.~~

2) Provide ~~2 position or modulating type valves, electrically actuated by line voltage of 120V.~~ Pressure independent control valves with actuator (PICV). See Section 230523 for more information.

~~3. Dampers:~~

~~a. Provide automatic control dampers as indicated, with damper frames not less than formed 13 gauge galvanized steel.~~

~~b. Provide mounting holes for enclosed duct mounting.~~

~~c. Provide damper blades not less than formed 16 gauge galvanized steel, with maximum blade width of 8 inch.~~

~~d. Equip dampers with motors of proper rating for each application.~~

~~e. Secure blades to 1/2 inch diameter zinc plated axles using zinc plated hardware.~~

~~1) Seal off against spring stainless steel blade bearings.~~

~~2) Provide blade bearings of Nylon and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc plated steel and brass.~~

~~3) Submit leakage and flow characteristics plus size schedule for controlled dampers.~~

~~f. Operating Temperature Range: From -20° to 200°F (-29° to 93°C).~~

~~g. For standard applications as indicated, provide parallel or opposed blade design (as selected by the manufacturer's sizing techniques) with optional closed cell neoprene edging.~~

~~h. For low leakage applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with inflatable steel blade edging or replaceable rubber seals, rated for leakage less than 10 cfm per square foot of damper area, at differential pressure of 4 inch w.g. when damper is being held by torque of 50 inch pounds.~~

~~4.~~3. Damper and Valve Motors, Actuators:

a. Size each motor to operate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified.

~~b. Pneumatic driven DDC controlled actuators are acceptable for large valves and dampers in buildings with compressed air systems.~~

~~c. Equip motors for outdoor locations and for outside air intakes with "O-ring" gaskets designed to make motors completely weatherproof, and equip with internal heaters to permit normal operation at -20°F.~~

~~d.~~b. Furnish nonspring return motors for dampers larger than 25 square feet and for valves larger than 2-1/2 inches, sized for running torque rating of 150 inch-pounds and breakaway torque rating of 300 inch-pounds. Size spring-return motors for running torque rating of 150 inch-pounds and breakaway torque rating of 150 inch-pounds.

~~5. Ionization Smoke Detectors:~~

~~a. For each air handling unit provide UL-listed ionization smoke detectors in main supply and return air ducts, as required by NFPA 90, and where indicated.~~

~~b. Connect detectors into control circuits to stop fans in presence of smoke.~~

~~6.~~4. Electric Contactors:

a. Provide contactors for operating or limit-control of electric heating loads, which are UL-listed for 100,000 cycles of resistive loads.

b. Equip with replaceable molded coils and replaceable silver cadmium oxide contacts.

c. Coat core laminations with heat-resistant inorganic film to reduce core losses.

d. Provide line and load terminals on contactors with higher-than-35-amp rating, or provide one-piece formed-and-welded pressure type.

e. Provide screw-type contactors for 35-amp-or-lower rating.

f. Equip field-mounted contactors with suitable steel enclosures.

g. Provide open-type mounting for those installed in factory-fabricated panels.

~~7. Water Flow Switches:~~

~~a. Provide water flow switches of stainless steel or bronze paddle types.~~

~~b. Where flow switches are used in chilled water applications, provide vapor-proof type to prevent condensation on electrical switch.~~

~~c. Provide pressure-flow switches of bellows actuated mercury type or snap-acting type, with appropriate scale range and differential adjustment for service indicated.~~

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which control systems are to be installed.

B. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 ERECTION INSTALLATION APPLICATION

A. General:

1. Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

2. Install electrical components and use electrical products complying with the requirements of applicable Division 26 sections of the Specifications.

B. Unit Mounted Equipment: Where control devices are indicated to be unit-mounted, ship electric relays, electric switches, valves, dampers, and motors to system manufacturer for mounting and wiring at factory.

C. Control Wiring:

1. Install control wiring, without splices between terminal points, color-coded.

2. Install in accordance with the National Electrical Code.

3. The term "control wiring" is defined to include providing of wiring, conduit, and miscellaneous materials as required for mounting and connecting control devices.

4. Install circuits over 25V with color-coded No. 12 wire in electric metallic tubing (EMT).

5. Install circuits under 25V with color-coded No. 18 wire with 0.031-inch high temperature (105°F (41°C)) plastic insulation on each conductor and plastic sheath over all.

6. Install electronic circuits with color-coded No. 22 wire with 0.023-inch polyethylene insulation on each conductor with plastic jacketed copper shield over all.

7. Install low voltage circuits, located in concrete slabs and masonry walls, or exposed in occupied areas, in electrical conduit.

D. Number-code or color-code conductors, excluding those used for local individual room controls, appropriately for future identification and servicing of control system.

E. Reset Limit Controls: Install manual-reset limit controls to be independent of power controllers.

F. Room temperature transmitters shall be installed a minimum of 70" AFF. Occupant adjustable temperature controls shall be mounted at 48" AFF to meet ADA requirements.

3.3 ADJUSTING

A. Startup: Startup, test, and adjust control systems. Demonstrate compliance with requirements.

1. Coordinate with other contractors as required to start-up, test, balance and adjust all systems. Replace damaged or malfunctioning controls and equipment.

2. Do not place systems into operation until all components are complete and in place, all testing and inspection has been performed and authorization of Owner has been received.

B. Final Adjustment: After completion of installation, adjust thermostats, control valves, motors, and similar equipment provided as work of this section.

3.4 CLEANING

A. Clean factory-finished surfaces. Repair any marred or scratched surfaces and manufacturer's touch-up paint.

3.5 DEMONSTRATION

A. Operator Instructions:

1. During system commissioning and at such time acceptable performance of the control system hardware and software has been established, the Building Automation Contractor shall provide on-site operator instruction to NREL personnel. Operator instruction during normal working hours shall be performed by a competent Building Automation Contractor representative familiar with the control system's software, hardware, and accessories.

~~2. At a time mutually agreed upon during control system commissioning as stated above, the Building Automation Contractor shall:~~

~~a. Give at least 8 hours of instruction to the NREL designed personnel at the NREL job site on the operation of all equipment within the building automation center and describe its intended use with respect to the programmed functions specified.~~

~~b. 32 hours of additional training requirements may be fulfilled by off site training classes, for a total of 40 hours of training.~~

~~c. Operator orientation of the automation system shall include, but not be limited to, the overall operational program, equipment functions (both individually and as part of the total integrated system), commands, system generation, advisories, and appropriate operator intervention required in responding to the control system's operation.~~

~~d. An Owner's manual prepared for this project by the Building Automation Contractor shall be used in addition to the instruction. Four copies of the Owner's manual shall be provided.~~

END OF SECTION 230900

SECTION 232113
HYDRONIC PIPING

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 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, and specialties for the following:

1. Hot-water heating piping.
2. ~~Chilled-water piping.~~
3. ~~Dual-temperature heating and cooling water piping.~~
4. ~~Condenser-water piping.~~
5. ~~Glycol cooling-water piping.~~
6. ~~Makeup-water piping.~~
7. ~~Condensate-drain piping.~~
8. ~~Blowdown-drain piping.~~
9. ~~Air-vent piping.~~
10. ~~Safety-valve-inlet and -outlet piping.~~

1.3 REFERENCES

A. American Society of Mechanical Engineers (ASME)

1. B1.20.1 - Pipe Threads, General Purpose (Inch).
2. B16.3 - Malleable Iron Threaded Fittings.
3. B16.5 - Pipe Flanges and Flanged Fittings.
4. B16.9 - Factory-Made Wrought Steel Buttwelding Fittings.
5. B16.11 - Forged Steel Fittings, Socket-Welding and Threaded.
6. B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
7. B18.2.1 - Square and Hex Bolts and Screws - Inch Series.
8. B18.2.2 - Square and Hex Nuts (Inch Series).
9. B18.22.1 - Plain Washers.
10. B31.3 - Process Piping.
11. B36.10 - Welded and Seamless Wrought Steel Pipe.

B. American National Standards Institute (ANSI)

C. American Society for Testing and Materials (ASTM)

D. American Welding Society (AWS)

E. A5.8 - Specifications for Brazing Filler Metal

F. American Water Works Association (AWWA)

G. Cast Iron Soil Pipe Institute (CISPI)

1. Cast Iron Soil Pipe and Fittings Handbook.

H. Copper Development Association (CDA)

1. Copper Tube Handbook.

I. Factory Mutual (FM)

1. 1680 - Approved Standard for Couplings Used in Hubless Cast Iron Systems for Drain, Waste, or Vent, Sewer, Rainwater or Storm Drain Systems Above and Below Ground, Industrial/Commercial and Residential.

J. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)

1. SP-43 - Wrought Stainless Steel Butt-Welding Fittings.

K. National Sanitation Foundation (NSF)

1.4 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

B. CW: Continuous Weld.

C. ERW: Electric Resistance Weld.

1.5 SUBMITTALS

A. Refer to Division 23 sections of the Specifications.

B. Product Data: For each type of the following:

1. Pipe and fittings.

2. Pressure-seal fittings.

3. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

4. Air control devices.

5. Chemical treatment.

6. Hydronic specialties.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

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. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.7 WARRANTY

A. Follow the procedures Specified in Division 1.

~~1.8 EXTRA MATERIALS~~

~~A. Water Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.~~

~~B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.~~

PART 2 - PRODUCTS

~~2.1 BEDDING AND BACKFILL MATERIALS~~

~~A. Granular Material~~

~~1. Crushed stone or pea gravel which will pass the 4 inch sieve but will be retained on the No. 4 sieve (U.S.A. Standard Series).~~

~~B. Sieves~~

~~1. ASTM E11.~~

~~C. Sand~~

~~1. Natural particles of granular material which does not contain excessive amounts of clay, silt, or organic material, passing a 3/8 inch sieve. Sand found on the job site may be used if it is approved by the Architect.~~

~~2.2~~2.1 PIPING MATERIALS - ABOVEGROUND

A. Heating Hot Water~~, Chilled Water, Condenser Water, and Glycol~~.

Item	Type Joint	Size	Class or Pressure Rating	Material &/ or Spec'n.	Remarks
~~Tubing~~Pipe		up through NPS 2	Type L	Type L Copper ASTM B88M (B88)	Hard drawn*
~~Pipe~~		~~NPS 2 1/2 through NPS 10~~	~~Sch. 40~~	~~ASTM A53 ASME B36.10M~~	~~Seamless, CW or ERW Blk. Stl. Grade B~~
~~Pipe~~		~~NPS 12 & up~~	~~.375 in. wall thick.~~	~~ASTM A53 ASME B36.10M~~	~~Seamless, CW or ERW Blk. Stl. Grade B~~

Item	Type Joint	Size	Class or Pressure Rating	Material &/ or Spec'n.	Remarks
Fittings	Solder	up through NPS 2	Type L	ASME B16.22	Wrought Copper
~~Fittings~~	~~Weld.~~	~~NPS 2-1/2 & up~~	~~Std. Wt.~~	~~ASTM A234~~	~~Forged Steel~~
~~Flanges~~		~~NPS 2-1/2 & up~~	~~150 lb~~	~~ASTM A181~~	~~Grade 1~~
Unions	Solder	up through NPS 2	150 lb	ASTM B62	Brass
Thread Sealant		1/2 inch wide x 4 mils thick		Teflon	Ribbon

PART 3 - EXECUTION

3.1 ABOVEGROUND PIPING INSTALLATION

A. General

1. Install pipe and pipe fittings in accordance with recognized industry practices to achieve permanently leakproof systems, capable of performing the indicated service without failure.
2. Install each piping run with a minimum number of joints and couplings but with adequate and accessible unions/flanges for disassembly and maintenance/replacement of valves and equipment.
3. Install piping with sufficient clearance from other piping, building structure and other systems to allow for the piping insulation to be properly applied.
4. Run piping above ground parallel with the lines of the building unless otherwise shown or noted.
5. Keep horizontal runs of piping as high as possible to provide maximum head room.
6. Install piping in equipment rooms so as not to interfere with aisleways and to allow unhindered egress from any point in the space.
7. Keep vertical lines straight in the partitions or furring or as close to the columns as possible.
8. Run pipe to avoid interference with ducts, wires or apparatus and with approved offsets around columns, beams and other obstructions.
9. Install piping that penetrates a vapor retarder to respect the vapor retarder integrity by sealing the opening around the pipe with vapor retardant tape.
10. Install piping with sufficient clearance from building structural members so as not to interfere with the application of steel fireproofing.
11. Establish piping elevations prior to installation to avoid interferences with other piping and materials and equipment of other trades.
12. Cutting, burning, or welding of structural steel is not permitted, unless indicated otherwise.

B. Personnel Protection From Suspended Work

1. Refer to Division 23 sections of the Specifications.

C. Pitching of Piping

1. Pitch horizontal water and air lines to low points to provide for complete drainage of the system. Minimum pitch, unless otherwise shown: 1 inch in 40 feet. Install drain valves at low points and air vents at high points and at locations where air may pocket on water lines.

2. Pitch steam piping at a uniform grade of 0.2 percent downward in the direction of steam flow.

3. Pitch gravity condensate return piping at a uniform grade of 0.4 percent in the direction of condensate flow.

D. Separation of Piping

1. Separate cold piping from hot piping with a minimum of 6 inches air gap between outside diameters of the piping. If piping is insulated, locate the 6-inch air gap between outside diameters of the insulation.

E. Drains

1. Pipe drains from items such as boilers, water relief valves, tanks, cooling coil drain pans, air vents, environmental rooms evaporator condensate drain pans, and drip-pan elbows, to the nearest floor drain.

F. Copper Tubing

1. Swaging copper tubing to couple two lengths together instead of using an approved solder type coupling will not be permitted. Incompletely filled solder joints are not acceptable.

2. Make up horizontal joints on piping NPS 2-1/2 and larger in the vertical position before assembly and erection.

3. Clean surfaces to be soldered both the inside of the fitting and the outside of the tubing, with steel wool or fine sandpaper until all discoloration is removed and metal is smooth and bright.

4. In assembling copper tube systems, take care to establish proper grade and alignment in the system before soldering. Installations will not be approved where tube and fittings are subjected to strain in order to obtain grade or alignment.

5. File or ream cut tube ends to the full original bore.

3.2 PIPE JOINTING

~~A. Steel Pipe~~

~~1. Provide steel pipe NPS 2 and smaller with plain ends and socket weld joints or threaded ends and screwed joints. Provide sizes NPS 2-1/2 and over flanged and welded.~~

~~2. Ream pipe ends and take care to prevent foreign material from entering any pipe.~~

~~3. Make screwed joints with oil and graphite or other approved compound. Apply joint compound to male thread only and take care to prevent compound from reaching interior of pipe.~~

~~4. Install unions or companion flanges in the pipe lines at locations as required to permit the removal of fixtures, apparatus and equipment without dismantling. Do not install unions and companion flanges in walls, partitions or other inaccessible locations.~~

~~B.~~A. Copper Pipe

1. Solder joint connections

a. Use ASTM B813, water flushable, lead-free flux; ASTM B32, lead-free solder; and ASTM B828 procedure, unless otherwise indicated.

b. Use a multiple-flame circular torch for soldering tubing NPS 2-1/2 and larger.

c. For joints in potable water systems, use flux and solder which complies with NSF 61.

~~2. Make copper press fittings in accordance with the manufacturer's installation instructions. Fully insert the tubing into the fitting and mark the tubing at the shoulder of the fitting. Before pressing the fitting, check the fitting alignment against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. Press the joints on the tubing using the tool approved by the manufacturer.~~

~~C. Pipe Welding~~

~~1. Perform steel pipe welding by either oxy-acetylene or electric arc method and perform by approved welders qualified in accordance with the Division 23 sections of the Specifications. Use welding procedures and provide joint quality which strictly conforms to above procedures. The Architect reserves the right to require qualifying demonstrations, at the Contractor's expense, of any welders assigned to the job.~~

~~2. Make tee connections in welded piping with a factory fabricated butt welding tee or with weld-o-let of butt, socket or threaded type. When weld-o-lets are used provide a branch connection which is one-half the diameter of the main or less. Scarf welding or direct butt welding of side connections will not be permitted. Tees fabricated from pipe will not be permitted.~~

~~3. Use long radius welding ells wherever possible, in changing pipe directions of welded pipe lines. Mitered joints are not acceptable.~~

~~D. Flanges~~

~~1. Provide flanges with 1/16 inch raised and drilled face, of the weld neck type. Slip-on type flanges will not be allowed.~~

~~2. Where flanges with raised faces are joined to companion flanges with a flat face, machine the raised face down to a smooth matching surface and use full face gasket.~~

~~3. Provide gaskets suitable for the liquid or gas service intended. Gaskets containing asbestos material will not be permitted.~~

~~E.~~B. Reducing Fittings

1. For proper drainage and air elimination, provide eccentric type fittings when decrease in pipe size is necessary. Bushings will not be permitted.

2. For water and other liquid lines, install the top of pipe on a continuous straight line.

3. ~~For steam, gas, gravity condensate, and air lines, install the bottom of the pipe on a continuous straight line.~~

END OF SECTION 232113

SECTION 232123
HYDRONIC PUMPS

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 SUMMARY

A. This Section includes:

~~1. Base-Mounted, Close-Coupled, End-Suction Pumps.~~

~~2.~~1. Inline pumps.

~~3. Base-Mounted, End Suction Pumps.~~

1.3 REFERENCES

A. Applicable Standards:

1. American National Standards Institute (ANSI) B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
2. American standards for Testing and Materials (ASTM)
   a. B36 - Brass Plate, Sheet, Strip, and Rolled Bar
   b. B584 - Copper Alloy Sand Castings for General Applications
3. Institute of Electrical and Electronics Engineers (IEEE) 112 - Test Procedure for Polyphase Induction Motors and Generators
4. Hydraulic Institute (HI)
5. National Electrical Manufacturers' Association (NEMA) MG-1 - Motors and Generators
6. National Fire Protection Association (NFPA) 70 - National Electrical Code (NEC)
7. Underwriters Laboratories (UL) 778 - Motor Operated Water Pumps.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 23 section “Common Work Results for HVAC”:

1. Product data including certified performance curves of selected models indicating selected pump's operating point, weights (shipping, installed, and operating), furnished specialties and accessories.
2. Shop drawings showing layout and connections for HVAC pumps. Include setting drawings with templates and directions for installation of foundation bolts and other anchorages.
3. Wiring diagrams detailing wiring for power, signal, and control systems, differentiating between manufacturer-installed wiring and field installed wiring.
4. Maintenance data for HVAC pumps for inclusion in Operating and Maintenance Manual specified elsewhere in Division 23.

1.5 QUALITY ASSURANCE

A. HI Compliance: Design, manufacture, and install HVAC pumps in accordance with Hydraulic Institute Standards.

B. NEC Compliance: Provide components complying with NFPA 70.

C. UL Compliance: Provide HVAC pumps, which are listed and label by UL and comply with UL 778.

D. NEMA Compliance: Provide electric motors and components that are listed and labeled NEMA.

E. Single Source Responsibility: Obtain HVAC pumps from a single manufacturer.

F. Design Criteria: The Drawings indicate sizes, profiles, connections, and dimensional requirements of HVAC pumps and are based on the specific manufacturer types and models indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided deviations in dimensions, profiles, pump curves, and efficiencies do not change the design concept or intended performance as judged by the Owner.

G. Dimension Deviations: Subcontractor is responsible to install the supplied pumps. Any interferences or alterations arising from using pumps different from those specified in the design documents must be remedied by the Subcontractor at no expense to NREL. This applies even to pumps with approved submittals. Remedies must be in a neat, workmanlike manner.

1.6 DELIVERY, STORAGE AND PROTECTION

A. Store pumps in a dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. For storage times greater than five days, dry internal parts with hot air or a vacuum-producing device to avoid rusting internal parts. Upon drying, coat internal parts with a protective liquid such as light oil, kerosene, or antifreeze. Dismantle bearings and couplings, dry and coat them with an acid-free heavy oil, and then tag and store in dry location.

1.7 WARRANTY

A. See procedures specified in Division 1 sections of the Specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide one of the following:

~~1. Base-Mounted, Close-Coupled, End-Suction Pumps~~

~~a. Goulds "2000 Series"~~

~~b. Bell & Gossett, ITT "Series 1531"~~

~~2. Base-Mounted, Horizontal, End Suction Pumps~~

~~a. Goulds - "2000 Series"~~

~~b. Bell & Gossett, ITT "Series 1510"~~

~~3.~~1. Close-Coupled, In-line, Horizontal or Vertical Mounted Pumps

~~a. Goulds PIC "2500 Series"~~

a. ~~Bell & Gossett, ITT "Series 80"~~Grundfos

b. Or Equal

Formatted: English (United States)

2.2 MANUFACTURED UNITS

A. Pumps, General:

1. Pumps and Circulators: Factory-assembled and factory-tested. Fabricate casings to allow removal and replacement of impellers without necessity of disconnecting piping. Type, sizes, and capacities shall be as indicated.
2. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anti corrosion compound. Protect flanges, pipe openings, and nozzles.
3. Motors: Conform to NEMA MG-1, general purpose, continuous duty, Design_B, except Design C where required for high starting torque; single, multiple, or variable speed with type of enclosure and electrical characteristics as indicated; have built-in thermal-overload protection; and grease-lubricated ball bearings. Select motors that are non-overloading within the full range of the pump performance curve.
4. Efficiency: "Energy Efficient" motors shall have a minimum efficiency as indicated in accordance with IEEE 112, Test Method B. If efficiency is not specified, motor shall have a higher efficiency than the "average standard industry motors," in accordance with IEEE 112, Test Method B.
5. Apply factory finish paint to assembled, tested units prior to shipping.

B. Pumps:

1. General Description: Pumps shall be centrifugal, single-stage, bronze-fitted, design, and rated for 175 psig working pressure and 225°F continuous water temperature.
2. Casings Construction: Cast iron with flanged piping connections and threaded gauge tappings at inlet and outlet flange connections.
3. Impeller Construction: Statically and dynamically balanced, closed, overhung single-suction, fabricated from cast bronze conforming to ASTM B584, keyed to shaft, and secured by a locking cap screw.
4. Wear Rings: Replaceable, bronze.
5. Pump Shaft and Sleeve Bearings: Steel shaft with bronze sleeve. Provide flinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.
6. Seals: Mechanical seals consisting of flushed seals of a carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.
7. Motor: Direct-mounted to pump casing with supporting legs as an integral part of motor enclosure. Provide with variable frequency drive.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of HVAC pumps.

B. Examine rough in for piping systems to verify actual locations of piping connections prior to installation.

C. Examine equipment foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 ERECTION INSTALLATION APPLICATION

A. General: Comply with the manufacturer's written installation and alignment instructions.

1. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

2. Support pumps and piping separately so that the weight of the piping system does not rest on the pump.

3. Suspend inline pumps using all-thread hanger rod and vibration isolation hangers of sufficient size to support the weight of the pump, independent from the piping system.

~~4. Set base-mounted pumps on a concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until the alignment operations have been completed.~~

~~a. Support pump base plate on rectangular metal blocks and shims, or on metal wedges having a small taper, at points near the foundation bolts to provide a gap of 3/4 to 1-1/2 inches between the pump base and the foundation for grouting. Grout pump bases with non-shrink grout.~~

~~b. Adjust the metal supports or wedges until the shafts of the pump and driver are level. Check the coupling faces and suction and discharge flanges of the pump to verify that they are level and plumb.~~

B. Alignment:

1. Align pump and motor shafts and piping connections after ~~setting on foundations, after grout has been set and foundations bolts have been tightened,~~equipment supports have been tightened and after piping connections have been made.

a. Adjust alignment of pump and motor shafts for angular and parallel alignment by method detailed in NREL Alignment Specification.

2. After alignment is correct, tighten ~~the foundation bolts~~equipment supports and hanger rods evenly but not too firmly. ~~Fill the base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.~~

a. Alignment tolerances shall meet manufacturer's recommendations.

C. Connections:

1. General: Install valves that are same size as the piping connecting the pump.

2. Install suction and discharge pipe sizes equal to or greater than the diameter of the pump nozzles.

3. Install a nonslam check valve matching the pipe size on the discharge side of the pump. Install a butterfly (over 2 inch pipe size) or ball (2 inch and under) isolation valve on the discharge side of inline pumps. Isolation valves are to be installed downstream of the check valve.

4. Install a butterfly (over 2 inch pipe size) or ball valve (2 inch and under) on the suction side of inline pumps.

~~5. Install a pump suction diffuser and butterfly valve on the suction side of base-mounted, end-suction pumps.~~

~~6.~~5. Install flexible connectors on the suction and discharge side of each base-mounted pump. Install flexible connectors between the pump casing and the discharge valves and upstream from the pump suction diffuser.

~~7.~~6. Install temperature and pressure gauge connector plugs in suction and discharge piping around pump. Temperature and pressure gauge connector plugs are specified in Division 23 sections of the Specifications. Where shown on drawings, install differential pressure gauge tree across pump suction and discharge.

~~8.~~7. Electrical wiring and connections are specified in Division ~~1~~26 sections of the Specifications.

~~9.~~8. Control wiring and connections are specified in other Division ~~15~~ 23 sections of the Specifications.

D. Commissioning:

1. Final Checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:
   a. Lubricate oil-lubricated bearings.
   b. Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer's recommendations.
   c. Disconnect coupling and check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
   d. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.
2. Starting procedure for pumps with shutoff power not exceeding the safe motor power:
   a. Prime the pump, open the suction valve, closing the drains, and prepare the pump for operation.
   b. Open the sealing liquid supply valve if the pump is so fitted.
   c. Start the motor.
   d. Slowly open the discharge valve.
   e. Observe for leakage from the mechanical seal. Stop pump immediately if mechanical seal leaks.
   f. Check the general mechanical operation of the pump and motor.
3. If the pump is to be started against a closed check valve with the discharge gate valve open, the steps are the same, except that the discharge isolation valve is opened some time before the motor is started.
   a. Refer to related Division 23 sections of the Specifications for detailed requirements for testing, adjusting, and balancing hydronic systems.

3.3 FIELD QUALITY CONTROL

A. Check suction line connections for tightness to avoid drawing air into the pump.

B. Check all connections for tightness to avoid water leakage.

C. Subcontractor is responsible for cleaning up and repairing damage due to leaking joints.

END OF SECTION 232123

~~****DESIGN CONSULTANT TO REMOVE NREL DESIGNER NOTES IN RED PRIOR TO 100% "ISSUE FOR CONSTRUCTION" DELIVERABLE****~~

SECTION 233113
METAL DUCTS

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 SUMMARY

A. This Section includes rectangular and round metal ducts and plenums for heating, ventilating, and air conditioning systems in pressure classes from -2 inches to +10 inches water gauge.

1.3 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:

1. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.

2. Joints: Joints include girth joints; branch and sub branch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum and casing abutments to building structures.

1.4 PERFORMANCE REQUIREMENTS

A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modifications with calculations showing that the proposed layout will provide the original design results without increasing the system total pressure.

B. 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.

C. 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" and ASCE/SEI 7. SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.

2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.

3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.5 SUBMITTALS

A. General: Submit the following in accordance with related sections of Division ~~23~~ 1 Specifications.

1. Product data including details of construction relative to materials, dimensions of individual components, profiles and finishes for the following items:

   a. Duct Liner.

   b. Sealing Materials.

   c. Fire-Stopping Materials.

   ~~**NOTE: DESIGN CONSULTANT TO PROVIDE MATERIAL SPECIFICATION SHEETS (CUT SHEETS) AS PART OF DESIGN CALCULATIONS & ANALYSIS DELIVERABLE**~~

2. Coordination drawings for ductwork installation in accordance with Division 23 sections of the Specifications, in addition to the requirements specified in Division 23 sections of the Specifications, show the following:

   a. Coordination with ceiling suspension members.

   b. Spatial coordination with other systems installed in the same space with the duct systems.

   c. Coordination of ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.

   d. Coordination with ceiling-mounted lighting fixtures and air outlets and inlets.

3. Record drawings including duct systems routing, fittings details, reinforcing, support and installed accessories, and devices in accordance with Division 23 sections of the Specifications.

4. Maintenance data for volume control devices in accordance with Division 23 sections of the Specifications.

1.6 QUALITY ASSURANCE

A. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)

B. American Society for Testing and Materials (ASTM)

1. A36 - Structural Steel

2. A366 - Steel, Carbon, Cold-Rolled Sheet, Commercial Quality

3. A480 - General Requirements for Flat-Rolled Stainless and Heat Resisting Steel Plate, Sheet and Strip

4. A527 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality

5. A700 - Packing, Marking and Loading Methods for Steel Products for Domestic Shipment

6. B209 - Aluminum and Aluminum-Alloy Sheet and Plate

7. C411 - Hot-Surface Performance of High-Temperature Thermal Insulation

8. C916 - Adhesives for Duct Thermal Insulation

9. C920 - Elastomeric Joint Sealants

10. C1071 - Thermal and Acoustical Insulation (Mineral Fiber, Duct Lining Material)

11. E814 - Fire Tests of Through-Penetration Fire Stops

C. American Welding Society (AWS)

1. D1.1 - Structural Welding Code - Steel
2. D9.1 - Welding of Sheet Metal

D. Federal Specifications (FS)

1. FS TT-S-001657 - Sealing Compound, Single Component Butyl Rubber Based, Solvent Release Type (for Buildings and Other Types of Construction)

E. National Fire Protection Association (NFPA)

1. 90A - Installation of Air Conditioning and Ventilating Systems
2. 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment

F. Sheet Metal and Air-Conditioning Contractors National Association (SMACNA)

G. Thermal Insulation Manufacturers Association (TIMA)

1. AHC-101 - Duct Liner Materials

H. Underwriters Laboratories (UL)

1. 181 - Factory-Made Air Ducts and Air Connectors

1.7 DELIVERY, STORAGE, AND PROTECTION

A. Deliver sealant and fire-stopping materials to site in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time and mixing instruction for multi-component materials.

B. Store and handle sealant fire-stopping materials in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

C. Deliver and store stainless steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Sheet Metal Materials

1. Sheet Metal, General: Provide sheet metal in thicknesses indicated, packaged and marked as specified in ASTM A700.
2. Galvanized Sheet Steel: Lock-forming quality, ASTM A527, Coating Designation G90. Provide mill phosphatized finish for surfaces of ducts exposed to view.
3. Reinforcement Shapes and Plates: Unless otherwise indicated, provide galvanized steel reinforcing where installed on galvanized sheet metal ducts. For aluminum and stainless steel ducts, provide reinforcing of compatible materials.
4. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

B. Duct Liner

1. General: Comply with NFPA 90A and TIMA AHC-101.
2. Materials: ASTM C1071, Type II, with coated surface exposed to airstream to prevent erosion of glass fibers.
    a. Thickness: 1 inch.
    b. Density: 1-1/2 pounds.
3. Thermal Performance: "K-Factor" equal to 0.28 or better, at a mean temperature of 75°F.
4. Fire Hazard Classification: Flame spread rating of not more than 25 without evidence of continued progressive combustion and a smoke developed rating of no higher than 50, when tested in accordance with ASTM C411.
5. Liner Adhesive: Comply with NFPA 90A and ASTM C916.
6. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct. Provide fasteners that do not damage the liner when applied as recommended by the manufacturer, that do not cause leakage in the duct, and will indefinitely sustain a 50-pound tensile dead load test perpendicular to the duct wall.
    a. Fastener Pin Length: As required for thickness of insulation, and without projecting more than 1/8 inch into the air stream.
    b. Adhesive for Attachment of Mechanical Fasteners: Comply with the "Fire Hazard Classification" of duct liner system.

C. Sealing Materials
1. Joint and Seam Sealants, General: The term sealant used here is not limited to materials of adhesive of mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.
2. Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant complying with FS TT-S-001657, Type I; formulated with a minimum of 68% solids.
3. Flanged Joint Mastics: One-part, acid curing, silicone elastomeric joint sealants, complying with ASTM C920, Type S, Grade NS, Class 25, Use O.

D. Hangers and Supports
1. Building Attachments: Concrete inserts, or structural steel fasteners appropriate for building materials. Do not use powder-actuated concrete fasteners for lightweight aggregate concretes or for slabs less than 4 inches thick.
2. Hangers: Galvanized sheet steel or round, uncoated steel, threaded rod.
    a. Straps and Rod Sizes: Conform with Table 4-1 in SMACNA "HVAC Duct Construction Standards," 1985 Edition, for sheet steel width and gauge and steel rod diameters.
3. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
4. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36.
    a. Where galvanized steel ducts are installed, provide hot-dipped-galvanized steel shapes and plates.

2.2 FABRICATION

A. Rectangular Duct Fabrication

1. General: Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "HVAC Duct Construction Standards," Tables 1-3 through 1-19, including their associated details. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.

    a. Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

    b. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains and discolorations.

2. Static Pressure:

    a. Supply Ducts: 3 inches water gauge.

    b. Return Ducts: 2 inches water gauge, negative pressure.

    c. Exhaust Ducts: 2 inches water gauge, negative pressure.

3. Cross breaking or Cross Beading: Cross break or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standard," Figure 1-4, unless they are lined or are externally insulated.

B. Rectangular Duct Fittings

1. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," 1985 Edition, Figures 2-1 through 2-10.

C. Shop Application of Liner in Rectangular Ducts

1. Adhere a single layer of indicated thickness of duct liner with 90% coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.

2. Apply a coat of adhesive to liner facing in direction of airflow not receiving metal nosing.

3. Butt transverse joints without gaps and coat joints with adhesive.

4. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.

5. Longitudinal joints in rectangular ducts shall not occur except at corners of ducts, unless the size of the duct and standard liner product dimensions make longitudinal joints necessary.

6. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter, at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

7. Secure transversely oriented liner edges facing the air stream with metal nosings that are either channel or "Z" profile or are integrally formed from the duct wall at the following locations:

    a. Fan discharge.

    b. Intervals of lined duct preceding unlined duct.

8. Terminate liner with duct build outs installed in ducts to attach dampers, turning vane assemblies, and other devices. Fabricated build outs (metal hat sections) or other build out means are optional; when used, secure build outs to the duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire damper sleeve through fire separation.

~~**NOTE: ALL LABORATORY DUCT TO BE ROUND.**~~

D. Round Duct Fabrication

1. Round Ducts: Fabricate round supply ducts with spiral lock seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams. Comply with SMACNA "HVAC Duct Construction Standards," Table 3-2 for galvanized steel gauges.

E. Round Supply and Exhaust Fittings Fabrication

1. 90º Tees and Laterals and Conical Tees: Fabricate to conform to SMACNA "HVAC Duct Construction Standards," 1985 Edition, Figures 3-4 and 3-5 and with metal thicknesses specified for longitudinal seam straight duct.

2. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from the body onto branch tap entrance.

3. Elbows: Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate the bend radius of die-formed, gored, and pleated elbows 1.5 times the elbow diameter. Unless elbow construction type is indicated, provide elbows meeting the following requirements.

a. Mitered Elbows: Fabricate mitered elbows with welded construction in gauges specified below.

1) Mitered Elbows Radius and Number of Pieces: Unless otherwise indicated, construct elbow to comply with SMACNA "HVAC Duct Construction Standards," Table 3-1.

2) Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from -2 inches to +2 inches.

a) 3 to 26 inches: 24-gauge.

~~b) 27 to 36 inches: 22-gauge.~~

~~c) 37 to 50 inches: 20-gauge.~~

~~d) 52 to 60 inches: 18-gauge.~~

~~e) 62 to 84 inches: 16-gauge.~~

3) Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from 2 inches to 10 inches.

a) 3 to 14 inches: 24-gauge.

~~b) 15 to 26 inches: 22-gauge.~~

~~c) 27 to 50 inches: 20-gauge.~~

~~d) 52 to 60 inches: 18-gauge.~~

~~e) 62 to 84 inches: 16-gauge.~~

4) 90°, 2-Piece, Mitered Elbows: Use only for supply systems, or exhaust system for material handling classes A and B; and only where space restrictions do not permit the use of 1.5-bend radius elbows. Fabricate with a single-thickness turning vanes.

b. Round Elbows - 8 Inches and Smaller: Die-formed elbows for 45- and 90° elbows and pleated elbows for 30°, 45°, 60° and 90° only. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g., 3-1/2- and 4-1/2-inch) elbows with gored construction.

c. Round Elbows - 9 through 14 Inches: Gored or pleated elbows for 30°, 45°, 60° and 90° except where space restrictions require a mitered elbow. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g., 9-1/2- and 10-1/2-inch) elbows with gored construction.

d. Round Elbows - Larger than 14 Inches and All Flat Oval Elbows: Gored elbows, except where space restrictions require a mitered elbow.

e. Die-Formed Elbows for Sizes through 8 Inches and All Pressures: 20-gauge with 2-piece welded construction.

f. Round Gored Elbows Gauges: Same as for nonelbow fittings specified above.

g. Pleated Elbows Sizes through 14 Inches and Pressures through 10 Inches: 26-gauge.

~~2.3 LABORATORY EXHAUST~~

~~A. Materials~~

~~1. PVC Coating: All laboratory exhaust ductwork, fittings and dampers shall be fabricated using galvanized sheet steel as specified above (2.1) with a coating of polyvinyl chloride of not less than 1 mils thickness external and not less than 4 mils thickness internal. The contractor shall fabricate this duct in a fashion to minimize any damage to the coating. The contractor shall spray coat PVC and repaint any damaged areas. All joints and seems to be made air tight.~~

~~2. Joint and Seam Sealants: Sealant is to be chemically resistant and compatible for PCD applications. McGill Airseal UNI-COAT duct sealer or equivalent.~~

~~3. Stainless Steel: ASTM A 480, Type 316, sheet form with No. 4 finish for surfaces of ducts exposed to view; and Type 304, sheet form with No. 1 finish for concealed ducts.~~

~~a. Round Ductwork: As specified for galvanized single wall round ductwork, except fabricate the ducts of 316 stainless steel a minimum 20 gage with fully welded fittings.~~

~~b. Rectangular Ductwork: As specified for galvanized rectangular ductwork, except fabricate the ducts of 316 stainless steel with a minimum 20 gage.~~

~~4. Joints: Fully welded.~~

~~NOTE: DESIGN CONSULTANT TO DETERMINE MATERIAL AND MODIFY THE FOLLOWING SPECIFICATION BASED ON THE BUILDING WHERE WORK IS BEING PERFORMED.~~

~~Science & Technology Facility~~

~~DUCT SERVICE~~	~~TYPE/CONNECTION~~

Supply air between fan and terminal boxes	Galvanized steel
Rectangular supply air from discharge of terminal box/fan to air devices	Galvanized steel painted blue
Return air ductwork	Galvanized steel (PCD where noted) painted red
General building exhaust	Galvanized steel painted red
Laboratory exhaust, fume hoods, mains and branches to exhaust valves	304 Stainless steel all welded construction
Toxic gas storage	304 Stainless steel all welded construction up to exhaust fan
Main laboratory exhaust air branches front penthouse	PVC coated as noted on drawings painted red

Alternative Fuel User Facility

DUCT SERVICE	TYPE/CONNECTION
Supply air between fan and terminal boxes	Galvanized steel
Rectangular supply air from discharge of terminal box/fan to air devices	Galvanized steel
Return air ductwork	Galvanized steel (PCD where noted)
General building exhaust	Galvanized steel
Laboratory exhaust, fume hoods, mains and branches to exhaust valves	304 Stainless steel all welded construction
Toxic gas storage	304 Stainless steel all welded construction up to exhaust fan
Bio-safety fume hoods	304 Stainless steel all welded construction
New IBRF Lab Exhaust	PVC Coated duct painted white
Main laboratory exhaust air branches front penthouse	304 Stainless steel to exhaust fans
Dishwasher exhaust, Autoclave hood	304 Stainless steel

Solar Energy Research Facility

DUCT SERVICE	TYPE/CONNECTION
Supply air between fan and terminal boxes	Galvanized steel
Rectangular supply air from discharge of terminal box/fan to air devices	Galvanized steel painted white

Return air ductwork	Galvanized steel (PVC lined where noted) painted white
General building exhaust	Galvanized steel painted white
Laboratory exhaust, fume hoods, mains and branches to exhaust valves	PVC lined galvanized painted white
Bio-safety fume hoods	PVC lined galvanized painted white
Main laboratory exhaust air branches front penthouse	PVC lined galvanized painted white

Field Test Laboratory Building

DUCT SERVICE	TYPE/CONNECTION
Supply air between fan and terminal boxes	Galvanized steel
Rectangular supply air from discharge of terminal box/fan to air devices	Galvanized steel painted blue
Return air ductwork	Galvanized steel (PCD where noted) painted red
General building exhaust	Galvanized steel painted red
Laboratory exhaust, fume hoods, mains and branches to exhaust valves	PVC lined galvanized painted red
Bio-safety fume hoods	PVC lined galvanized painted red
Main laboratory exhaust air branches front penthouse	PVC lined galvanized painted red

Thermal Test Facility

DUCT SERVICE	TYPE/CONNECTION
Supply air between fan and terminal boxes	Galvanized steel
Rectangular supply air from discharge of terminal box/fan to air devices	Galvanized steel painted blue
Return air ductwork	Galvanized steel painted red
General building exhaust	Galvanized steel painted red
Exhaust snorkels and drops	Galvanized steel

Outdoor Test Facility

DUCT SERVICE	TYPE/CONNECTION
Supply air between fan and terminal boxes	Galvanized steel

~~Rectangular supply air from discharge of terminal box/fan to air devices~~	~~Galvanized steel painted blue~~
~~Return air ductwork~~	~~Galvanized steel painted red~~
~~General building exhaust~~	~~Galvanized steel painted red~~

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. Duct Installation, General

1. Duct System Pressure Class: Construct and install each duct system for the specific dust pressure classification indicated.
2. Install ducts with the fewest possible joints.
3. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.
4. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
5. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

3.2 FIELD QUALITY CONTROL

A. Disassemble, reassemble, and seal segments of the systems as required to accommodate leakage testing and as required for compliance with test requirements.

B. Conduct tests, in the presence of the Engineer, at static pressures equal to the maximum design pressure of the system or the section being tested. If pressure classifications are not indicated, test entire system at the maximum system design pressure. Do not pressurize systems above the maximum design operating pressure. Give seven days advance notice for testing.

C. Maximum Allowable Leakage: As described in ASHRAE 1989 Handbook, "Fundamentals" Volume, Chapter 32, Table 6 and Figure 10. Comply with requirements for leakage classification 3 for round and flat oval ducts, leakage classification 12 for rectangular ducts in pressure classifications less than and equal to 2 inches water gauge (both positive and negative pressures), and leakage classification 6 for pressure classifications greater than 2 inches water gauge and less than and equal to 10 inches water gauge.

1. NREL Technical Representative has the authority to require further duct sealing by the contractor if he determines there is excessive leakage. This determination may be based on noise, drafts, poor system performance, or other factors.

D. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.

E. Leakage Test: Perform volumetric measurements and adjust air systems as described in ASHRAE 1987 "HVAC Systems and Applications" Volume, Chapter 57; ASHRAE 1989 "Fundamentals" Volume, Chapter 13; and Division 23 sections of the Specifications.

3.3 ADJUSTING

A. Adjust volume control devices as required by the testing and balancing procedures to achieve required airflow. See Division 22 sections of the Specifications for requirements and procedures for adjusting and balancing air systems.

3.4 CLEANING

A. Vacuum duct systems prior to final acceptance to remove dust and debris.

END OF SECTION 233113

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SECTION 233300
AIR DUCT ACCESSORIES

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 SUMMARY

A. This Section includes:

~~1. Backdraft dampers~~

~~2.~~1. Manual volume control dampers

~~3.~~2. Actuators

~~4.~~3. Turning vanes

~~5.~~4. Duct-mounted access doors and panels

~~6.~~5. Flexible connectors

~~7.~~6. Flexible ducts

~~8.~~7. Accessories hardware

~~9. Fire/Smoke Damper~~

1.3 SUBMITTALS

A. General: Submit the following:

1. Product data including details for materials, dimensions of individual components, profiles, and finishes for the following items:

~~a. Backdraft dampers.~~

~~b.~~a. Manual volume control dampers.

~~c.~~b. Duct-mounted access panels and doors.

~~d.~~c. Flexible ducts.

2. Shop drawings from manufacturer detailing assemblies.

a. Include dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

b. Detail the following:

1) Special fittings and volume control damper installation (both manual and automatic) details.

2) Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installations.

3) Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installations.

1.4 QUALITY ASSURANCE

A. Comply with ASTM E84 – "Surface Burning Characteristics of Building Materials" and with ASTM E477 – "Testing Duct Liner Materials and Prefabricated Silencers for Acoustical and Airflow Performance."

B. Comply with NFPA 90A – "Installation of Air Conditioning and Ventilating Systems" and with NFPA 92B – "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with HVAC Duct Construction Standards per SMACNA - Metal & Flexible, 1st Ed., 1985.

D. Comply with UL 181 – "Factory-Made Air Ducts and Air Connectors," UL 555 – "Fire Dampers and Ceiling Dampers," and UL 555S – "Leakage Rate Dampers for Use in Smoke Control Systems."

PART 2 - PRODUCTS

2.1 MATERIALS

~~A. For laboratory exhaust systems, provide dampers and accessories that are PVC coated or stainless steel to match the existing ductwork.~~

~~B. Backdraft Dampers:~~

~~1. Description: Suitable for horizontal or vertical installation.~~

~~2. Frame: 18 gauge galvanized steel, with welded corners and mounting flange.~~

~~3. Blades: 0.025 inch thick roll formed aluminum.~~

~~4. Blade Seals: Neoprene.~~

~~5. Blade Axles: Galvanized steel.~~

~~6. Tie Bars and Brackets: Galvanized steel.~~

~~7. Return Spring: Adjustable tension.~~

~~8. Chain Operator: 15 foot long galvanized steel sash chain and pulley.~~

~~9. Wing Nut Operator: Galvanized steel, with 1/4 inch galvanized steel rod.~~

~~C.~~A. Manual Volume Control Dampers:

1. General:

   a. Provide factory-fabricated volume-control dampers, complete with required hardware and accessories.

   b. Stiffen damper blades to provide stability under operating conditions.

   c. Provide locking device to hold single-blade dampers in a fixed position without vibration.

   d. Close duct penetrations for damper components to seal duct consistent with pressure class.

   e. Provide end bearings or other seals for ducts with pressure classifications of 3 inches or higher.

   f. Extend axles full length of damper blades.

g. Provide bearings at both ends of operating shaft.

2. Standard Volume Control Dampers: Multiple- or single-blade, parallel-or opposed-blade design as indicated, standard leakage rating, with linkage outside of air stream, and suitable for horizontal or vertical applications.

   a. Steel Frames:

      1) Hat-shaped, galvanized-steel channels, minimum of 16 gauge and with mitered and welded corners.

      2) Provide frames with flanges where indicated for attaching to walls.

      3) Provide flangeless frames where indicated for installation in ducts.

   b. Roll-Formed Steel Blades: 16-gauge galvanized steel.

   c. Blade Axles: Galvanized steel.

   d. Tie Bars and Brackets: Galvanized steel.

~~3. Low-Leakage Volume Control Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside of air stream, and suitable for horizontal or vertical applications.~~

~~4. Low-Leakage Volume Control Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, and suitable for horizontal or vertical applications.~~

~~a. Steel Frames:~~

~~1) Hat-shaped, galvanized-steel channels, minimum of 16 gauge and with mitered and welded corners.~~

~~2) Provide frames with flanges where indicated for attaching to walls.~~

~~3) Provide flangeless frames where indicated for installation in ducts.~~

~~b. Roll-Formed Steel Blades: 16-gauge galvanized steel.~~

~~c. Extruded-Aluminum Blades: 0.050-inch-thick 6063T extruded aluminum.~~

~~d. Blade Seals: Neoprene.~~

~~e. Blade Axles: Galvanized steel.~~

~~f. Tie Bars and Brackets: Galvanized steel.~~

~~5. High-Performance Volume Control Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside of air stream, and suitable for horizontal or vertical applications.~~

~~a. Steel Frames:~~

~~1) Hat-shaped, galvanized-steel channels, minimum of 16 gauge and with mitered and welded corners.~~

~~2) Provide frames with flanges where indicated for attaching to walls.~~

~~3) Provide flangeless frames where indicated for installation in ducts.~~

~~b. Steel Blades: 18-gauge, airfoil-shaped, galvanized steel.~~

~~c. Blade Seals: Dual-durometer vinyl on blade edges; metallic compression on jambs.~~

~~d. Blade Axles: Galvanized steel.~~

~~e. Tie Bars and Brackets: Galvanized steel.~~

~~6.~~3. Jackshaft:

a. 1-inch-diameter, galvanized-steel pipe rotating within a pipe bearing assembly mounted on supports at each mullion and at each end of multiple damper assemblies.

b. Provide appropriate length and number of mounting to connect linkage of each damper of a multiple damper assembly.

~~7.~~4. Damper Control Hardware:

a. Zinc-plated, die-cast core with a heavy-gauge dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.

b. Provide center hole to suit damper operating rod size. Provide elevated platform for insulated duct mounting.

~~D.~~B. Turning Vanes:

1. Manufactured Turning Vanes: Fabricate of 1-1/2-inch-wide, curved blades set at 3/4-inch on center, support with bars perpendicular to blades set at 2 inches on center, and set into side strips suitable for mounting in ducts.

2. Acoustic Turning Vanes: Fabricate of airfoil-shaped aluminum extrusions with perforated faces and fiberglass fill.

~~E.~~C. Duct-mounted Access Doors and Panels:

1. General:

a. Refer to the Access Door Materials Schedule at the end of this section for frame and door thickness, number of hinges and locks, and location of locks.

b. Provide construction and air tightness suitable for duct pressure class.

2. Frame:

a. Galvanized sheet steel.

b. Provide with bend-over tabs and foam gaskets.

3. Door:

a. Double-wall, galvanized sheet metal construction with insulation fill and thickness, number of hinges and locks as indicated for duct pressure class.

b. Provide vision panel where indicated.

c. Provide 1" x 1" butt hinge or piano hinge and cam latches.

4. Seal around frame attachment to duct and door to frame with neoprene or foam rubber seals.

5. Insulation: 1-inch-thick fiberglass or polystyrene foam board.

~~F.~~D. Flexible Connectors:

1. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL Standard 181, Class 1.

2. Conventional, Indoor System Flexible Connectors Fabric: Glass fabric double coated with polychloroprene.

   a. Minimum Weight: 26 ounce per square yard.

   b. Tensile Strength: 480 pounds per inch in the warp and 360 pounds per inch in the filling.

~~G.~~E. Flexible Ducts:

1. General: Comply with UL 181, Class 1.

2. Flexible Ducts - Insulated:

   a. Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-1/2-inch-thick, glass fiber insulation around a continuous inner liner.

   b. Reinforcement: Steel-wire helix encapsulated in the inner liner.

   c. Outer Jacket: Glass-reinforced, silver mylar with a continuous hanging tab, integral fiberglass tape, and nylon hanging cord.

   d. Inner Liner: Polyethylene film.

~~H. FIRE/SMOKE DAMPERS~~

~~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 Balance Inc.; a division of Mestek, Inc.~~
~~b. Arrow United Industries; a division of Mestek, Inc.~~
~~c. Cesco Products; a division of Mestek, Inc.~~
~~d. Greenheck Fan Corporation.~~
~~e. Nailor Industries Inc.~~
~~f. NCA Manufacturing, Inc.~~
~~g. Pottorff.~~
~~h. Prefco; Perfect Air Control, Inc.~~
~~i. Ruskin Company.~~
~~j. Vent Products Company, Inc.~~
~~k. Ward Industries, Inc.; a division of Hart & Cooley, Inc.~~
~~l. Or Equal.~~

~~2. Type: Static; rated and labeled according to UL 555/UL555S by an NRTL.~~

~~3. Closing rating in ducts up to 4 inch wg static pressure class and minimum 2000 fpm velocity. Rated pressure and velocity to exceed design airflow conditions.~~

~~4. Fire Rating: [3] hours.~~

~~5. 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.~~

~~6. Mounting Sleeve: Factory or field installed, galvanized sheet steel.~~

a. Minimum Thickness: 0.138 inch or 0.39 inch thick, as indicated, and of length to suit application.
b. 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.

7. Mounting Orientation: Vertical or horizontal as indicated.

8. 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.

9. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

10. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

11. Smoke Detector: Integral, factory wired for single-point connection.

12. Leakage: Class II

13. Damper Motors: two-position action.

14. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

a. 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.
b. Permanent-Split Capacitor or Shaded-Pole Motors: With oil immersed and sealed gear trains.
c. Spring-Return Motors: Equip with an integral spiral spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
d. Electrical Connection: 115 V, single phase, 60 Hz

2.2 ACCESSORIES

A. Instrument Test Holes:

1. Cast iron or cast aluminum to suit duct material, including screw cap and gasket and a flat mounting gasket.

2. Size to allow insertion of pitot tube and other testing instruments and provide in length to suit duct insulation thickness.

B. Flexible Duct Clamps:

1. Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action.

2. Provide in sizes from 3 to 18 inches to suit duct size.

C. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of duct accessories.

B. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 ERECTION INSTALLATION APPLICATION

A. Install duct accessories according to manufacturer's installation instructions and applicable portions of details of construction as shown in SMACNA standards.

B. Install volume control dampers in lined duct with methods to avoid damage to liner and to avoid erosion of duct liner.

C. Provide test holes at fan inlet and outlet and elsewhere as indicated.

~~D. Install fire and smoke dampers according to the manufacturer's UL-approved printed instructions.~~

~~E.~~D. Label access doors according to Division 23 sections of the Specifications.

3.3 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual dampers is specified in Division 23 sections of the Specifications.

3.4 SCHEDULES

A. Access Door Materials Schedule: *(S: Side, T: Top, B: Bottom)*

DUCT PRESSURE CLASS	DOOR SIZE (INCHES)	NUMBER OF HINGES	NUMBER OF LOCKS	METAL GAUGE FRAME	DOOR	BACK
2 INCHES & LESS	12 X 12	2	1 – S	24	26	26
	16 X 20	2	2 - S	22	24	26
	24 X 24	3	2 - S	22	22	26
3 INCHES	12 X 12	2	1 – S	22	22	26
	16 X 20	2	1 - S, 1 - T, 1 - B	20	20	26
	24 X 24	3	2 - S, 1 - T, 1 - B	20	20	24
4 INCHES TO 10 INCHES	12 X 12	2	1 - S, 1 - T, 1 – B	20	20	26
	16 X 20	3	2 - S, 1 - T, 1 - B	20	18	24
	24 X 24	3	2 - S, 2 - T, 2 - B	18	18	24

END OF SECTION 233300

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SECTION 233600
AIR TERMINAL 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:

~~1. Bypass, single-duct air terminal units.~~
~~2.~~1. Shutoff, single-duct air terminal units.
~~3. Parallel, fan-powered air terminal units.~~
~~4. Series, fan-powered air terminal units.~~
~~5. Dual-duct air terminal units.~~
~~6. Induction air terminal units.~~
~~7. Diffuser-type air terminal units.~~
~~8. Balancing terminal units.~~
~~9. Pressure control terminal units.~~
~~10. Critical environment control valve.~~
~~11. Underfloor air distribution terminal units.~~
~~12. Underfloor air distribution floor induction units.~~
~~13. Exhaust single-duct terminal units.~~
~~14. Casing liner.~~

1.3 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".

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

1.4 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. Sealants and gaskets.

3. Seismic-restraint devices.

B. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 – "Systems and Equipment" and Section 7 – " Construction and System Start-Up."

PART 2 - PRODUCTS

~~2.1 BYPASS, SINGLE-DUCT AIR TERMINAL UNITS~~

~~A. <Double click here to find, evaluate, and insert list of manufacturers and products.>~~

~~B. Configuration: Diverting damper assembly inside unit casing with control components inside a protective metal shroud.~~

~~C. Casing: [**0.040-inch- (1.0-mm-**)] [**0.034-inch- (0.85-mm-**)] <**Insert dimension**> thick galvanized steel, single wall.~~

~~1. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.~~

~~D. Diverter Assembly: [**Galvanized-steel gate, with polyethylene linear bearings**] [**Aluminum blade, with nylon-fitted pivot points**].~~

~~E. Multioutlet Attenuator Section: With [**two**] [**three**] [**four**] <**Insert number**> [**6-inch- (150-mm-**)] [**8-inch- (200-mm-**)] [**10-inch- (250-mm-**)] diameter collars, each with locking butterfly balancing damper.~~

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [**fibrous glass**] [**flexible elastomeric**] duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

G. Electric Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Stage(s): [**1**] [**2**] [**3**].
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
8. Mercury contactors.
9. Pneumatic-electric switches and relays.
10. Magnetic contactor for each step of control (for three-phase coils).

H. Electric Controls: Damper actuator and thermostat.

1. Damper Actuator: 24 V, powered closed, powered open[**with microswitch to energize heating control circuit**].
2. Thermostat: Wall-mounted electric type with temperature display in Fahrenheit and Celsius, and space temperature set point.
3. Changeover Thermostat: Duct-mounted, field-adjustable, electric type reverses action of zone thermostat when air temperature reaches 70 deg F (21 deg C).

I. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Thermostat: Wall-mounted electronic type with the following features:

a. Temperature set-point display in Fahrenheit and Celsius.
b. Auxiliary switch to energize heating control circuit.
c. Changeover thermistor to reverse action.

J. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

~~2.2~~2.1 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Krueger.
2. METALAIRE, Inc.
3. Price Industries.
4. Titus.
5. Trane.
6. Or Equal.

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, 1/2-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 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 inlet 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.

D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

F. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

~~G. Electric Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine staked terminals secured with stainless steel hardware.~~

~~1. Stage(s): [1] [2] [3].~~
~~2. SCR controlled.~~
~~3. Access door interlocked disconnect switch.~~
~~4. Downstream air temperature sensor with local connection to override discharge air temperature to not exceed a maximum temperature set point (adjustable).~~
~~5. Nickel chrome 80/20 heating elements.~~
~~6. Airflow switch for proof of airflow.~~
~~7. Fan interlock contacts.~~
~~8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).~~
~~9. Mercury contactors.~~
~~10. Pneumatic-electric switches and relays.~~
~~11. Magnetic contactor for each step of control (for three-phase coils).~~

~~H.~~G. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230900 "Instrumentation and Control for HVAC."

1. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
2. Control Sequences:

   a. Occupied:
      1) In a call for cooling, airflow will increase as the damper opens towards maximum setting to satisfy set point.
      2) In a call for less cooling, airflow will decrease as the damper closes towards minimum setting to satisfy set point.
   b. Unoccupied:
      1) Damper closes to minimum setting; upon a call for heating damper opens to heating setting and hydronic coil control valve modulates to satisfy set point.

~~2.3 PARALLEL FAN-POWERED AIR TERMINAL UNITS~~

~~A. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud. [**Designed for quiet operation.**] [**Low-profile design.**]~~

~~B. Casing: [**0.040-inch- (1.0-mm-**)] [**0.034-inch- (0.85-mm-**)] <**Insert dimension**> thick galvanized steel, single wall.~~

~~1. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.~~
~~2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.~~
~~3. Air Outlet: S-slip and drive connections.~~
~~4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.~~
~~5. Fan: Forward-curved centrifugal, located at plenum air inlet.~~
~~6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.~~

C. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, [**2**] [**3**] percent of nominal airflow at [**3-inch wg (750-Pa)**] [**6-inch wg (1500-Pa)**] inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

D. Velocity Sensors: Multipoint array with velocity sensors.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: [**Permanent-split capacitor with SCR for speed adjustment**] [**Electronically commutated motor**].
3. Fan Motor Assembly Isolation: Rubber isolators.
4. Enclosure: [**Open dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
5. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
6. Motor Bearings: <**Insert requirements**>.
7. Unusual Service Conditions:

    a. Ambient Temperature: <**Insert deg F (deg C)**>.
    b. Altitude: <**Insert feet (m)**> above sea level.
    c. High humidity.
    d. <**Insert conditions**>.

8. Efficiency: Premium efficient.
9. NEMA Design: <**Insert designation**>.
10. Service Factor: <**Insert value**>.
11. Motor Speed: [**Single speed**] [**Multispeed**].

    a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.

12. Electrical Characteristics:

    a. Horsepower: <**Insert horsepower**>.
    b. Volts: [**120**] [**208**] [**230**] [**460**] <**Insert value**>.
    c. Phase: [**Single**] [**Poly**].
    d. Hertz: 60.
    e. Full-Load Amperes: <**Insert value**>.
    f. Minimum Circuit Ampacity: <**Insert value**>.
    g. Maximum Overcurrent Protection: <**Insert amperage**>.

F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.

2. Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.
3. Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
4. Thickness: [**2 inches (50 mm)**] [**1 inch (25 mm)**].

G. Attenuator Section: [**0.034-inch (0.85-mm) galvanized steel**] [**0.032-inch (0.8-mm) aluminum**] sheet.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

H. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

1. Location: Plenum air inlet.

I. Electric Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless-steel hardware.

1. Location: Plenum air inlet.
2. Stage(s): [**1**] [**2**] [**3**].
3. SCR controlled.
4. Access door interlocked disconnect switch.
5. Downstream air temperature sensor with local connection to override discharge air temperature to not exceed a maximum temperature set point (adjustable).
6. Nickel chrome 80/20 heating elements.
7. Airflow switch for proof of airflow.
8. Fan interlock contacts.
9. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
10. Mercury contactors.
11. Pneumatic-electric switches and relays.
12. Magnetic contactor for each step of control (for three-phase coils).

J. Factory Mounted and Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory mounted, fuse type.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

L. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Pneumatic Damper Operator: [**0- to 13-psig (0- to 90-kPa)**] <**Insert range**> spring range.
3. Electronic Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted pneumatic type [**direct acting**] [**reverse acting**] [**direct or reverse acting as indicated on Drawings**] with appropriate mounting hardware.
6. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure independent, VAV 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:

M. Control Sequence:

1. Occupied (Primary Airflow On):

a. Operate as throttling control for cooling.
b. As cooling requirement decreases, control valve throttles toward minimum airflow.
c. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve is energized**].

2. Unoccupied (Primary Airflow Off):

a. When pressure at primary inlet is zero or less, fan is de-energized.
b. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve will be energized**].

2.4 SERIES FAN-POWERED AIR TERMINAL UNITS

A. Configuration: Volume damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud [**for installation above a ceiling**] [**and**] [**within a raised access floor**].

1. Designed for quiet operation.

2. Low-profile design.

B. Casing: [**0.040-inch- (1.0-mm-)**] [**0.034-inch- (0.85-mm-)**] <**Insert dimension**> thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, [**2**] [**3**] percent of nominal airflow at [**3-inch wg (750-Pa)**] [**6-inch wg (1500-Pa)**] inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

D. Velocity Sensors: Multipoint array with velocity sensors in air inlets and air outlets.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: [**Permanent-split capacitor with SCR for speed adjustment**] [**Electronically commutated motor**].
3. Fan Motor Assembly Isolation: Rubber isolators.
4. Enclosure: [**Open drippproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
5. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
6. Motor Bearings: <**Insert requirements**>.
7. Unusual Service Conditions:

    a. Ambient Temperature: <**Insert deg F (deg C)**>.
    b. Altitude: <**Insert feet (m)**> above sea level.
    c. High humidity.
    d. <**Insert conditions**>.

8. Efficiency: Premium efficient.
9. NEMA Design: <**Insert designation**>.
10. Service Factor: <**Insert value**>.
11. Motor Speed: [**Single speed**] [**Multispeed**].

    a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.

12. Electrical Characteristics:

a. Horsepower: <**Insert horsepower**>.
b. Volts: [**120**] [**208**] [**230**] [**460**] <**Insert value**>.
c. Phase: [**Single**] [**Poly**].
d. Hertz: 60.
e. Full-Load Amperes: <**Insert value**>.
f. Minimum Circuit Ampacity: <**Insert value**>.
g. Maximum Overcurrent Protection: <**Insert amperage**>.

F. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.
2. Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.
3. Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
4. Thickness: [**2 inches (50 mm)**] [**1 inch (25 mm)**].

G. Attenuator Section: [**0.034-inch (0.85-mm) galvanized steel**] [**0.032-inch (0.8-mm) aluminum**] sheet.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

H. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

I. Electric Resistance Heating Coils: Nickel chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine staked terminals secured with stainless steel hardware.

1. Stage(s): [**1**] [**2**] [**3**].
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
9. Mercury contactors.
10. Pneumatic-electric switches and relays.
11. Magnetic contactor for each step of control (for three-phase coils).

J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

L. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Pneumatic Damper Operator: [**0- to 13-psig (0- to 90-kPa)**] <**Insert range**> spring range.
3. Electronic Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted pneumatic type [**direct acting**] [**reverse acting**] [**direct or reverse acting as indicated on Drawings**] with appropriate mounting hardware.
6. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure-independent, VAV 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 Division 23 Section "Instrumentation and Control for HVAC."

M. Control Sequence:

1. Occupied (Primary Airflow On):

    a. Operate as throttling control for cooling.
    b. As cooling requirement decreases, control valve throttles toward minimum airflow.

c. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve is opened**].

2. Unoccupied (Primary Airflow Off):

a. When externally initiated, begin the morning warm-up/cool-down function. Damper drives to the fully open position without regard for the preset maximum.
b. When pressure at primary inlet is zero or less, fan is de-energized.
c. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve is opened**].

2.5 DUAL-DUCT AIR TERMINAL UNITS

A. Configuration: [**Mixing**] [**and**] [**non-mixing**] with two volume dampers inside unit casing with mixing attenuator section and control components inside a protective metal shroud[**with a third primary air inlet with volume damper**].

B. Casing: [**0.040-inch- (1.0-mm-)**] [**0.034-inch- (0.85-mm-)**] <**Insert dimension**> thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
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.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 3 percent of nominal airflow at [**3-inch wg (750-Pa)**] [**6-inch wg (1500-Pa)**] inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

D. Velocity Sensors: Multipoint array with velocity sensors in air inlets and air outlets.

E. Attenuator Section: [**0.034-inch (0.85-mm) galvanized steel**] [**0.032-inch (0.8-mm) aluminum**] sheet.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Multioutlet Attenuator Section: With [**two**] [**three**] [**four**] <**Insert number**> [**6-inch- (150-mm-)**] [**8-inch- (200-mm-)**] [**10-inch- (250-mm-)**] [**12-inch- (300-mm-)**] diameter collars, each with locking butterfly balancing damper.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [**fibrous glass**] [**flexible elastomeric**] duct liner.

G. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Pneumatic Damper Operator: [**0- to 13-psig (0- to 90-kPa)**] <**Insert range**> spring range.
3. Electronic Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.
6. Electronic Thermostat: Wall-mounted electronic type with temperature set point display in Fahrenheit and Celsius.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure independent, VAV 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:

H. Control Sequence:

1. [**System**] [**Room thermostat**] modulates VAV damper and dual duct damper.[**Room sensor reports temperature.**]
2. When Space Temperature Is below Set Point: Close VAV damper, open hot deck dampers and close cold deck dampers, then open VAV damper.
3. When Space Temperature Is above Set Point: Close VAV damper, close hot deck dampers and open cold deck dampers, then open VAV damper.
4. Occupancy sensor reports occupancy and enables occupied temperature set point.
5. Occupancy sensor switches set point from occupied setting to unoccupied setting.

2.6 INDUCTION AIR TERMINAL UNITS

A. Configuration: Volume damper assembly inside unit casing with mechanical induction damper mounted on casing and control components inside a protective metal shroud.

B. Casing: [**0.040 inch (1.0 mm)**] [**0.034 inch (0.85 mm)**] <**Insert dimension**> thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous glass**] [**flexible elastomeric**] duct liner.
2. Air Inlet: Round stub connection for duct attachment.

3. Air Outlet: S-slip and drive connections[**, size matching inlet size**].
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Fan: Forward-curved centrifugal.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, [**2**] [**3**] percent of nominal airflow at [**3-inch wg (750-Pa)**] [**6-inch wg (1500-Pa)**] inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

D. Induction Damper: Galvanized-steel, multiblade assembly with self-lubricating bearings.

E. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

F. Electric Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Stage(s): [**1**] [**2**] [**3**].
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
9. Mercury contactors.
10. Pneumatic-electric switches and relays.
11. Magnetic contactor for each step of control (for three-phase coils).

G. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Pneumatic Damper Operator: [**0- to 13-psig (0- to 90-kPa)**] <**Insert range**> spring range.
3. Electronic Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted pneumatic type [**direct acting**] [**reverse acting**] [**direct or reverse acting as indicated on Drawings**] with appropriate mounting hardware.

6. Electronic Thermostat: Wall-mounted electronic type with temperature set point display in Fahrenheit and Celsius.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure-independent, VAV 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:

H. Control Sequence:

1. Damper controlling induced air from ceiling plenum opens or closes in response to decrease or increase in primary to ensure constant discharge airflow.
2. As heating requirement increases, fan energizes to draw in warm plenum air.

a. Electric heat is energized in steps.
b. Electric heat modulates under SCR control.
c. Hot water coil valve is opened.

2.7 DIFFUSER-TYPE AIR TERMINAL UNITS

A. Configuration: Volume damper, diffuser, controller assembly[**and electric heater**] and wall-mounted thermostat[**with master-slave capability**].

B. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

C. Diffuser: Galvanized steel with white baked-enamel finish.

D. Control Sequence: Diffusion dampers open and close to regulate airflow into the room in response to room temperature. The dampers are mechanically actuated by internal, factory-set thermal element thermostats[**with limited field adjustment**].

2.8 BALANCING TERMINAL UNITS

A. Configuration: Manually operated volume-damper assembly with locking mechanism inside unit casing with multipoint, center-averaging velocity sensors[**for installation above a ceiling**].

B. Casing: [**0.040-inch- (1.0-mm-**)] [**0.034-inch- (0.85-mm-**)] <**Insert dimension**> thick galvanized steel, single wall.

1. Leakage: Maximum 2 percent of nominal airflow at 3-inch wg (750 Pa) static pressure.
2. Air Inlet: Round stub connection for duct attachment.
3. Air Outlet: S-slip and drive connections.

4. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, [**2**] [**3**] percent of nominal airflow at [**3-inch wg (750 Pa)**] [**6-inch wg (1500 Pa)**] inlet static pressure.

D. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.9 PRESSURE CONTROL TERMINAL UNITS

A. Configuration: Volume damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: [**0.040-inch- (1.0-mm-)**] [**0.034-inch- (0.85-mm-)**] <**Insert dimension**> thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.
2. Air Inlet: Round stub connection for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to diverting damper and other 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.

C. Diverter Assembly: [**Galvanized-steel gate, with polyethylene linear bearings**] [**Aluminum blade, with nylon-fitted pivot points**].

D. Multioutlet Attenuator Section: With [**two**] [**three**] [**four**] <**Insert number**> [**6-inch- (150-mm-)**] [**8-inch- (200-mm-)**] [**10-inch- (250-mm-)**] diameter collars, each with locking butterfly balancing damper.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.

E. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and shall have the following features:

1. Static pressure tap for field installation.
2. Adjustable control module.

F. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

G. Control Sequence:

1. Under the control of a static pressure sensor, damper opens or closes to maintain static pressure downstream branch duct.

2.10 CRITICAL ENVIRONMENT CONTROL VALVE

A. Configuration: [**Volume damper**] [**Venturi valve**] assembly inside an externally insulated unit casing with control components inside a protective metal shroud.

B. Casing:

1. Type 316 stainless steel, 0.0375 inch (0.95 mm), with continuously welded seams.
2. [**Aluminum**] [**Heresite-coated aluminum**].
3. Galvanized steel.
4. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.

C. Sensors: Multipoint, Type 316 stainless steel[**, removable**].

D. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

E. Electric Resistance Heating Coils: Nickel chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine staked terminals secured with stainless steel hardware.

1. Stage(s): [**1**] [**2**] [**3**].
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge air temperature to not exceed a maximum temperature set point (adjustable).

F. Control Sequence:

1. Occupied (Primary Airflow On):

a. Operate as throttling control for cooling.
b. As cooling requirement decreases, control valve throttles toward minimum airflow.
c. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve is opened**].

2. Unoccupied (Primary Airflow Off):

a. When externally initiated, begin the morning warm-up/cool-down function. Damper drives to the fully open position without regard for the preset maximum.

b. When pressure at primary inlet is zero or less, fan is de-energized.
c. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve is opened**].

2.11 UNDERFLOOR AIR DISTRIBUTION TERMINAL UNITS

A. Configuration: Volume damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud within a raised access floor. Designed for [**pressurized floor cavity supply**] [**and**] [**ducted air supply**].

B. Casing: [**0.040 inch (1.0 mm)**] [**0.034 inch (0.85 mm)**] <**Insert dimension**> thick galvanized steel, single wall.

1. Integral floor discharge diffusers.
2. Mixing damper.
3. VAV throttling damper.
4. Leveling feet.
5. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous glass**] [**flexible elastomeric**] duct liner.
6. Air Outlet: S-slip and drive connections.
7. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
8. Fan: Forward-curved centrifugal [**in double blower configuration**] [**with double blowers as indicated**].
9. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, [**2**] [**3**] percent of nominal airflow at [**3-inch wg (750 Pa)**] [**6-inch wg (1500 Pa)**] inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

D. Velocity Sensors: Multipoint array with velocity sensors in air inlets and air outlets.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: [**Permanent-split capacitor with SCR for speed adjustment**] [**Electronically commutated motor**].
3. Fan Motor Assembly Isolation: Rubber isolators.
4. Enclosure: [**Open dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust ignition-proof machine**].
5. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
6. Motor Bearings: <**Insert requirements**>.

7. Unusual Service Conditions:

a. Ambient Temperature: <**Insert deg F (deg C)**>.
b. Altitude: <**Insert feet (m)**> above sea level.
c. High humidity.
d. <**Insert conditions**>.

8. Efficiency: Premium efficient.
9. NEMA Design: <**Insert designation**>.
10. Service Factor: <**Insert value**>.
11. Motor Speed: [**Single speed**] [**Multispeed**].
12. Electrical Characteristics:

a. Horsepower: <**Insert horsepower**>.
b. Volts: [**120**] [**208**] [**230**] [**460**] <**Insert value**>.
c. Phase: [**Single**] [**Poly**].
d. Hertz: 60.
e. Full-Load Amperes: <**Insert value**>.
f. Minimum Circuit Ampacity: <**Insert value**>.
g. Maximum Overcurrent Protection: <**Insert amperage**>.

F. Controller Type: [**Plenum Pressure Controllers**] [**Individual Diffuser Controller**] [**Terminal Unit Controller**].

G. Accessories:

1. Inlet filter.
2. Disconnect switch.
3. Transformers.
4. Airflow switch.

H. Control Sequence:

1. Occupied (Primary Airflow On):

a. Operate as throttling control for cooling.
b. As cooling requirement decreases, control valve throttles toward minimum airflow.
c. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve is opened**].

2. Unoccupied (Primary Airflow Off):

a. When externally initiated, begin the morning warm-up/cool-down function. Damper drives to the fully open position without regard for the preset maximum.
b. When pressure at primary inlet is zero or less, fan is de-energized.
c. As heating requirement increases, fan energizes to draw in warm plenum air[**and electric heat is energized in steps**][**and electric heat modulates under SCR control**][**and the hot-water coil valve is opened**].

2.12 UNDERFLOOR AIR DISTRIBUTION FLOOR INDUCTION UNITS

A. Configuration: Raised access floor mounting units with ducted primary air[**and hydronic coil(s)**]. Air is discharged to space through nozzles. Design includes secondary air induced from served space.

B. Casing: [**0.040-inch- (1.0-mm-)**] [**0.034-inch- (0.85-mm-)**] <**Insert dimension**> thick galvanized steel, single wall. Casing includes removable aluminum linear grille and plenum[**with interior painted black**].

1. Provide air mixing chamber.
2. Provide casing space for control valves and actuators.
3. Casing to have adjustable feet.

C. Hydronic Heating Coils: [**One row**] [**Two rows**] [**As indicated on Drawings**]. Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

1. Coils to be painted black.

2.13 EXHAUST SINGLE DUCT TERMINAL

A. Configuration: Volume damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: [**0.040-inch- (1.0-mm-)**] [**0.034-inch- (0.85-mm-)**] <**Insert dimension**> thick galvanized steel, single wall. Casing includes removable aluminum linear grille and plenum.

1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
2. Air Outlet: S-slip and drive connections[**, size matching inlet size**].
3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Regulator Assembly: System air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F (minus 18 to plus 60 deg C), shall be impervious to moisture and fungus, shall be suitable for 10-inch wg (2500-Pa) static pressure, and shall be factory tested for leaks.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, [**2**] [**3**] percent of nominal airflow at [**3-inch wg (750-Pa)**] [**6-inch wg (1500-Pa)**] inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

E. Attenuator Section: [**0.034-inch (0.85-mm) galvanized steel**] [**0.032-inch (0.8-mm) aluminum**] sheet.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.

F. Multioutlet Attenuator Section: With [**two**] [**three**] [**four**] <**Insert number**> [**6-inch- (150-mm-)**] [**8-inch- (200-mm-)**] [**10-inch- (250-mm-)**] diameter collars, each with locking butterfly balancing damper.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for [**fibrous-glass**] [**flexible elastomeric**] duct liner.

G. Electric Controls: Damper actuator and thermostat.

1. Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.

H. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
3. Thermostat: Wall-mounted electronic type with temperature set point display in Fahrenheit and Celsius.

I. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

J. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered open, [**spring**] [**capacitous**] return.
2. Terminal Unit Controller: Pressure-independent, VAV 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 230923 "Direct Digital Control (DDC) System for HVAC."

3. Pressure Sensor: Duct mounted with pressure set point adjustment[**and access for connection of portable operator terminal**].

~~K. Controls:~~

~~1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.~~
~~2. System-powered, wall-mounted thermostat.~~

~~L. Control Sequence:~~

~~1. Damper blade opens or closes to maintain differential pressure set point in response to upstream and downstream differential pressure sensors.~~

~~2.14 CASING LINER~~

~~A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."~~

~~1. Minimum Thickness: [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**].~~

~~a. Maximum Thermal Conductivity:~~

~~1) Type I, Flexible: [**0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)**] <**Insert value**> at 75 deg F (24 deg C) mean temperature.~~
~~2) Type II, Rigid: [**0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K)**] <**Insert value**> at 75 deg F (24 deg C) 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. [**Solvent**] [**Water**] Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.~~

~~B. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.~~

~~1. Minimum Thickness: [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**].~~
~~2. 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.~~
~~3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.~~

~~2.15~~2.2 HANGERS AND SUPPORTS

A. Steel Cables: Galvanized steel complying with ASTM A 603.

B. 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.

C. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

~~2.16~~2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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.

3.2 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 requirements for seismic-restraint devices in Section 230548 "Vibration Controls for HVAC Piping and Equipment."

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 NREL.

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 NREL 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.

3.3 TERMINAL UNIT 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.

3.4 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "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 230553 "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 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. 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.

D. Air terminal unit will be considered defective if it does not pass tests and inspections.

E. 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. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

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SECTION 233713
DIFFUSERS, REGISTERS, AND GRILLES

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. Round ceiling diffusers.~~
~~2. Rectangular and square ceiling diffusers.~~
~~3. Perforated diffusers.~~
~~4.~~1. Louver face diffusers.
~~5. Linear bar diffusers.~~
~~6. Linear slot diffusers.~~
~~7. Ceiling integral continuous diffusers.~~
~~8. Light troffer diffusers.~~
~~9. Round induction diffusers.~~
~~10. Linear floor diffuser plenums.~~
~~11. Drum louvers.~~
~~12. Modular core supply grilles.~~
~~13. Continuous tubular diffusers.~~
~~14. Adjustable bar [**registers**] [**grilles**] [**registers and grilles**].~~
~~15. Security [**registers**] [**grilles**] [**registers and grilles**].~~
~~16. Fixed face [**registers**] [**grilles**] [**registers and grilles**].~~
~~17. Linear bar grilles.~~

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. 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. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

~~A. Round Ceiling Diffuser <**Insert drawing designation**>:~~

~~1. Devices shall be specifically designed for variable-air-volume flows.~~
~~2. Material: [**Steel**] [**Aluminum**].~~
~~3. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <**Insert finish**>.~~
~~4. Face Style: [**Four**] [**Three**] [**Two**] cone.~~
~~5. Mounting: Duct connection.~~
~~6. Pattern: [**Fully adjustable**] [**Two-position horizontal**].~~
~~7. Dampers: [**Radial opposed blade**] [**Butterfly**] [**Combination damper and grid**].~~
~~8. Accessories:~~

~~a. Equalizing grid.~~
~~b. Plaster ring.~~
~~c. Safety chain.~~
~~d. Wire guard.~~
~~e. Sectorizing baffles.~~
~~f. Operating rod extension.~~

~~B. Rectangular and Square Ceiling Diffusers <**Insert drawing designation**>:~~

~~1. Devices shall be specifically designed for variable-air-volume flows.~~
~~2. Material: [**Steel**] [**Aluminum**].~~
~~3. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <**Insert finish**>.~~
~~4. Face Size: [**24 by 24 inches (600 by 600 mm)**] [**20 by 20 inches (500 by 500 mm)**] [**12 by 12 inches (300 by 300 mm)**] <**Insert dimensions**>.~~
~~5. Face Style: [**Three cone**] [**Four cone**] [**Plaque**].~~
~~6. Mounting: [**Surface**] [**T-bar**] [**Snap in**] [**Spline**] [**Mounting panel**].~~
~~7. Pattern: [**Fixed**] [**Two position**] [**Adjustable**].~~
~~8. Dampers: [**Radial opposed blade**] [**Butterfly**] [**Combination damper and grid**].~~

~~9. Accessories:~~

~~a. Equalizing grid.~~
~~b. Plaster ring.~~
~~c. Safety chain.~~
~~d. Wire guard.~~
~~e. Sectorizing baffles.~~
~~f. Operating rod extension.~~

~~C. Perforated Diffuser <**Insert drawing designation**>:~~

~~1. Devices shall be specifically designed for variable-air-volume flows.~~
~~2. Material: Steel backpan and pattern controllers, with [**steel**] [**aluminum**] face.~~
~~3. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <**Insert finish**>.~~
~~4. Face Size: [**12 by 12 inches (300 by 300 mm)**] [**24 by 12 inches (600 by 300 mm)**] [**36 by 12 inches (900 by 300 mm)**] [**48 by 12 inches (1200 by 300 mm)**] [**16 by 16 inches (400 by 400 mm)**] [**20 by 20 inches (500 by 500 mm)**] [**24 by 24 inches (600 by 600 mm)**] [**36 by 24 inches (900 by 600 mm)**] [**48 by 24 inches (1200 by 600 mm)**] <**Insert dimensions**>.~~
~~5. Duct Inlet: [**Round**] [**Square**].~~
~~6. Face Style: [**Flush**] [**Drop extended**].~~
~~7. Mounting: [**Surface**] [**T-bar**] [**Snap-in**] [**Spline**] [**Mounting panel**].~~
~~8. Pattern Controller: [**Four louvered deflector patches**] [**Fixed with curved blades at inlet**] [**Adjustable with louvered pattern modules at inlet**] [**None**].~~
~~9. Dampers: [**Opposed blade**] [**Radial opposed blade**] [**Butterfly**] [**Combination damper and grid**] [**Combination volume and fire**].~~
~~10. Accessories:~~

~~a. Equalizing grid.~~
~~b. Plaster ring.~~
~~c. Safety chain.~~
~~d. Wire guard.~~
~~e. Sectorizing baffles.~~
~~f. Operating rod extension.~~

~~D.~~A. Louver Face Diffuser:

1. Manufacturers: Subject to compliance with requirements:

   a. METALAIRE, Inc.
   b. Price Industries.
   c. Titus.
   d. Or Equal.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, white
5. Face Size: 24 x 24 inches.
6. Mounting: T-bar.
7. Pattern: Four-way core style.

8. Dampers: [**Radial opposed blade**] [**Butterfly**] [**Combination damper and grid**].
9. Accessories:

a. Square to round neck adaptor.
b. Adjustable pattern vanes.
c. Throw reducing vanes.
d. Equalizing grid.
e. Plaster ring.
f. Safety chain.
g. Wire guard.
h. Sectorizing baffles.
i. Operating rod extension.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser <**Insert drawing designation**>:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: [**Steel**] [**Aluminum**] [**Stainless steel**].
3. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
4. Narrow Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/4 inch (6 mm) apart, [**zero**] [**15**] degree deflection.
5. Wide Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/2 inch (13 mm) apart, [**zero**] [**15**] degree deflection.
6. Wide Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 1/2 inch (13 mm) apart, [**zero**] [**15**] [**30**] degree deflection.
7. Pencil Proof Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 7/16 inch (11 mm) apart, [**zero**] [**15**] [**30**] degree deflection.
8. [**One**] [**Two**]-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
9. Frame: [**1-1/4 inches (32 mm)**] [**1 inch (25 mm)**] [**3/4 inch (19 mm)**] [**1/2 inch (13 mm)**] [**3/16 inch (5 mm)**] wide.
10. Mounting Frame: [**Filter**] <**Insert frame size and style**>.
11. Mounting: [**Countersunk screw**] [**Concealed bracket**] [**Spring clip**].
12. Damper Type: [**Adjustable opposed-blade assembly**] [**Hinged single blade**].
13. Accessories: [**Plaster frame**] [**Directional vanes**] [**Alignment pins**] [**Core clips**] [**Blank-off strips**].

B. Linear Slot Diffuser <**Insert drawing designation**>:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material - Shell: [**Steel**] [**Aluminum**], [**insulated**] [**noninsulated**].
3. Material - Pattern Controller and Tees: Aluminum.
4. Finish - Face and Shell: [**Baked enamel, black**] <**Insert finish**>.
5. Finish - Pattern Controller: [**Baked enamel, black**] <**Insert finish**>.
6. Finish - Tees: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
7. Slot Width: [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**1-1/2 inches (38 mm)**].

8. Number of Slots: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.
9. Length: [**24 inches (600 mm)**] [**30 inches (750 mm)**] [**36 inches (900 mm)**] [**48 inches (1200 mm)**] [**60 inches (1500 mm)**].
10. Accessories: [**Plaster frame**] [**T-bar slot**] [**Center notch**] [**T-bar on inlet side**] [**T-bar on both sides**] [**T-bar clip on one side**] [**T-bar clips on both sides**].

C. Ceiling Integral Continuous Diffuser <**Insert drawing designation**>:
1. Slot Width: [**1 inch (25 mm)**] [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] [**2-1/2 inches (63 mm)**] [**3 inches (76 mm)**].
2. Section Length: [**12 feet (3.7 m)**] <**Insert dimension**>.
3. Straight and curved sections as required to accommodate layout.
4. Mitered tees and corners.
5. Pattern Controllers: [**24 inches (600 mm)**] <**Insert dimension**> o.c.
6. Material: Aluminum, extruded, heavy wall.
7. Finishes:

    a. Exterior: Standard white.
    b. Interior: Standard black.

8. Throw: [**Standard**] [**High**].
9. Mounting: [**Ceiling**] [**Sidewall**].
10. Plenum: [**Noninsulated**] [**Insulated**].
11. Other Features:

    a. Painted interior.
    b. Blank-offs.

D. Light Troffer Diffuser <**Insert drawing designation**>:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel[**with external insulation**].
3. Finish: [**None**] [**Black enamel on visible surfaces**] <**Insert finish**>.
4. Slot Width: [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**1-1/2 inches (38 mm)**].
5. Number of Sides: [**One**] [**Two**].
6. Length: [**24 inches (600 mm)**] [**36 inches (900 mm)**] [**48 inches (1200 mm)**].
7. Pattern: [**Fixed**] [**Adjustable**].
8. Inlet: [**Top**] [**Side**].
9. Inlet Size: [**5 inches (125 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**].

2.3 UNDERFLOOR AIR DISTRIBUTION DIFFUSERS

A. Round Induction Diffusers <**Insert drawing designation**>:
1. Airflow Principle: Swirl-pattern induction.
2. Material: Plastic, high impact, and resistant to cart and foot traffic.
3. Color: [**Gray**] [**Black**].
4. Components:

    a. Diffuser core.
    b. Flow regulator.

c. Dirt and liquid catch pan.
d. Spacer flange.
e. Gasketed, underfloor compression ring.

B. Linear Floor Diffuser Plenums <**Insert drawing designation**>:
1. Material: Steel.
2. Finish: White baked acrylic.
3. Deflection: [**Zero**] [**15**] degrees.
4. Components:

a. Aluminum diffuser core.
b. Diffuser frame.
c. Plenum, 0.034-inch (0.85-mm) steel.

2.4 HIGH-CAPACITY DIFFUSERS

A. Drum Louver <**Insert drawing designation**>:
1. Airflow Principle: Extended distance for high airflow rates.
2. Material: Aluminum, heavy-gage extruded.
3. Finish: White baked acrylic.
4. Border: 1-1/4-inch (32-mm) width with countersunk screw holes.
5. Gasket between drum and border.
6. Body: Drum shaped; adjustable vertically.
7. Blades: Individually adjustable horizontally.
8. Mounting: Surface to [**duct**] [**wall**].
9. Inlet Width: [**6 inches (150 mm)**] [**10 inches (250 mm)**] [**12 inches (300 mm)**] [**15 inches (380 mm)**] <**Insert dimension**>.
10. Inlet Length: [**12 inches (300 mm)**] [**24 inches (600 mm)**] [**36 inches (900 mm)**] [**60 inches (1500 mm)**] <**Insert dimension**>.
11. Accessories:

a. Opposed-blade steel damper.
b. Duct-mounting collars with countersunk screw holes.

B. Modular Core Supply Grilles <**Insert drawing designation**>:
1. Throw: Extended distance for airflow rates.
2. Material: Steel.
3. Grilles per Unit: [**One**] [**Two**] [**Three**] [**Four**].
4. Finish: White baked acrylic.
5. Border: 1-1/2-inch (38-mm) width with countersunk screw holes.
6. Blades:

a. Airfoil, individually adjustable horizontally.
b. Double deflection.
c. Set in modules.

7. Modules: Removable; rotatable.
8. Mounting: Surface.
9. Accessory: Opposed-blade steel damper.

2.5 FLEXIBLE DIFFUSION OUTLETS

A. Continuous Tubular Diffuser <**Insert drawing designation**>:
1. Material: [**Flame-retardant, woven polyethylene fabric**] [**Flame-retardant, coated polyester and fiberglass fabric**] [**Flame-retardant, permeable polyester and fiberglass fabric**] [**Polyethylene**].
2. Duct Connection: Round.
3. Duct Connection Size: <**Insert inches (mm)**>.
4. Diffusion Hole Size: <**Insert inches (mm)**>.
5. Diffusion Hole Frequency - Number per 100 Feet (30 m): <**Insert number**>.
6. Accessories:

a. Quick-connect joint.
b. Snap hooks.
c. Cleanout zipper.
d. Condensate drain.

2.6 REGISTERS AND GRILLES

A. Adjustable Bar Register <**Insert drawing designation**>:
1. Material: [**Steel**] [**Aluminum**] [**Stainless steel**].
2. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
3. Face Blade Arrangement: [**Horizontal**] [**Vertical**] spaced [**3 inches (76 mm)**] [**1-1/2 inches (38 mm)**] [**3/4 inch (19 mm)**] [**1/2 inch (13 mm)**] apart.
4. Core Construction: [**Integral**] [**Removable**].
5. Rear Blade Arrangement: [**Horizontal**] [**Vertical**] spaced [**3/4 inch (19 mm)**] [**1/2 inch (13 mm)**] apart.
6. Frame: [**1-1/4 inches (32 mm)**] [**1 inch (25 mm)**] wide.
7. Mounting Frame: [**Filter**] <**Insert frame size and style**>.
8. Mounting: [**Countersunk screw**] [**Concealed**] [**Lay in**].
9. Damper Type: [**Adjustable opposed blade**] [**NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C)**].
10. Accessories:

a. [**Front**] [**Rear**] blade gang operator.
b. Filter.

B. Adjustable Bar Grille <**Insert drawing designation**>:
1. Material: [**Steel**] [**Aluminum**] [**Stainless steel**].
2. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
3. Face Blade Arrangement: [**Horizontal**] [**Vertical**] spaced [**3 inches (76 mm)**] [**1-1/2 inches (38 mm)**] [**3/4 inch (19 mm)**] [**1/2 inch (13 mm)**] apart.
4. Core Construction: [**Integral**] [**Removable**].
5. Rear Blade Arrangement: [**Horizontal**] [**Vertical**] spaced [**3/4 inch (19 mm)**] [**1/2 inch (13 mm)**] apart.
6. Frame: [**1-1/4 inches (32 mm)**] [**1 inch (25 mm)**] wide.
7. Mounting Frame: [**Filter**] <**Insert frame size and style**>.
8. Mounting: [**Countersunk screw**] [**Concealed**] [**Lay in**].

C. Security Register <**Insert drawing designation**>:
1. Security Level: [**Maximum**] [**Medium**] [**Minimum**] [**and suicide deterrent**].
2. Application: [**Ducted return**] [**Air transfer**] [**Barrier**].
3. Material: [**Steel**] [**Aluminum**].
4. Material Thickness: [**0.19 inch (4.8 mm)**] <**Insert dimension**>.
5. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
6. Face Arrangement:

    a. Shape: [**Square**] [**Rectangular**] [**Round**].
    b. Design: [**Fixed bar**] [**Perforated**] [**Lattice**].
    c. Frame: [**Yes**] [**No**].
    d. Deflection: [**Zero**] [**38**] degrees.
    e. Core: [**None**] [**Louvered**].
    f. 3/16 inch (5 mm) thick, front lattice plate with 2 by 2 inch (50 by 50 mm) square holes and 1 inch (25 mm) frets, 0.135 inch (3.43 mm) wire mesh, and 1/4 inch (6 mm) thick backer plate.
    g. 3/16 inch (5 mm) thick, perforated faceplate with 5/16 inch (8 mm) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
    h. 1 1/2 inch (38 mm) bars and mandrel tubes and rods with [**zero**] [**15**] degree deflection in 1 1/4 by 1 1/4 by 3/16 inch (32 by 32 by 5 mm) angle border.
    i. 1 3/8 inch (35 mm) bars and double mandrel tubes with [**zero**] [**15**] degree deflection in 1 3/4 inch (45 mm) angle border.

7. Damper Operation: [**None**] [**Face operated**] [**Rear operated**].
8. Damper Type: [**Adjustable opposed blade**] [**NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C)**].
9. Wall Sleeve: [**3/16 inch (5 mm) welded to face**] [**1/8 inch (3 mm) welded to face**] [**Mechanically fastened to border**].
10. Mounting: [**1 by 1 by 3/16 inch (25 by 25 by 5 mm) retaining angle frame**] [**1 1/4 by 1 1/4 by 3/16 inch (32 by 32 by 5 mm) retaining angle frame**] [**1 1/4 by 1 1/4 by 3/16 inch (32 by 32 by 5 mm) cast in place frame and tamperproof machine screws**].

D. Security Grille <**Insert drawing designation**>:
1. Security Level: [**Maximum**] [**Medium**] [**Minimum**] [**and suicide deterrent**].
2. Application: [**Ducted return**] [**Air transfer**] [**Barrier**].
3. Material: [**Steel**] [**Aluminum**].
4. Material Thickness: [**0.19 inch (4.8 mm)**] <**Insert dimension**>.
5. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
6. Face Arrangement:

    a. Shape: [**Square**] [**Rectangular**] [**Round**].
    b. Design: [**Fixed bar**] [**Perforated**] [**Lattice**].
    c. Frame: [**Yes**] [**No**].
    d. Deflection: [**Zero**] [**38**] degrees.
    e. Core: [**None**] [**Louvered**].
    f. 3/16 inch (5 mm) thick, front lattice plate with 2 by 2 inch (50 by 50 mm) square holes and 1 inch (25 mm) frets, 0.135 inch (3.43 mm) wire mesh, and 1/4 inch (6 mm) thick backer plate.

g. 3/16 inch (5 mm) thick perforated faceplate with 5/16 inch (8 mm) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
h. 1-1/2 inch (38 mm) bars and mandrel tubes and rods with [**zero**] [**15**] degree deflection in 1-1/4 by 1-1/4 by 3/16 inch (32 by 32 by 5 mm) angle border.
i. 1-3/8 inch (35 mm) bars and double mandrel tubes with [**zero**] [**15**] degree deflection in 1-3/4 inch (45 mm) angle border.

7. Wall Sleeve: [**3/16 inch (5 mm) welded to face**] [**1/8 inch (3 mm) welded to face**] [**Mechanically fastened to border**].
8. Mounting: [**1 by 1 by 3/16 inch (25 by 25 by 5 mm) retaining angle frame**] [**1-1/4 by 1-1/4 by 3/16 inch (32 by 32 by 5 mm) retaining angle frame**] [**1-1/4 by 1-1/4 by 3/16 inch (32 by 32 by 5 mm) cast-in-place frame and tamperproof machine screws**].

E. Fixed Face Register <**Insert drawing designation**>:
1. Material: [**Steel**] [**Aluminum**].
2. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
3. Face Arrangement: [**1/2 by 1/2 by 1/2 inch (13 by 13 by 13 mm) grid**] [**Perforated**] core.
4. Core Construction: [**Integral**] [**Removable**].
5. Frame: [**1-1/4 inches (32 mm)**] [**1 inch (25 mm)**] wide.
6. Mounting Frame: [**Filter**] <**Insert frame size and style**>.
7. Mounting: [**Countersunk screw**] [**Concealed**] [**Lay in**].
8. Damper Type: [**Adjustable opposed blade**] [**NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C)**].
9. Accessory: Filter.

F. Fixed Face Grille <**Insert drawing designation**>:
1. Material: [**Steel**] [**Aluminum**].
2. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
3. Face Arrangement: [**1/2 by 1/2 by 1/2 inch (13 by 13 by 13 mm) grid**] [**Perforated**] core.
4. Core Construction: [**Integral**] [**Removable**].
5. Frame: [**1-1/4 inches (32 mm)**] [**1 inch (25 mm)**] wide.
6. Mounting Frame: [**Filter**] <**Insert frame size and style**>.
7. Mounting: [**Countersunk screw**] [**Concealed**] [**Lay in**].
8. Accessory: Filter.

G. Linear Bar Grille <**Insert drawing designation**>:
1. Material: [**Steel**] [**Aluminum**].
2. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
3. Face Arrangement: [**1/2 by 1/2 by 1/2 inch (13 by 13 by 13 mm) grid**] [**Perforated**] core.
4. Distribution plenum.

a. Internal insulation.
b. Inlet damper.

~~5. Frame: [**1-1/4 inches (32 mm)**] [**1 inch (25 mm)**] wide.~~
~~6. Mounting Frame: [**Filter**] <**Insert frame size and style**>.~~
~~7. Mounting: [**Countersunk screw**] [**Concealed**] [**Lay in**].~~
~~8. Damper Type: [**Adjustable opposed blade**] [**NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C)**].~~

~~2.7~~2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 260500
COMMON WORK RESULTS FOR ELECTRICAL

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 SUMMARY

A. This Section includes basic electrical requirements and work results applicable to Divisions 26, 27, and 28 of the Specifications.

B. Design Intent:

1. The Contract documents indicate and specify the electrical design intent. The Contract drawings are schematic and diagrammatic and are not intended to indicate construction details and routing unless specifically indicated. The specifications establish minimum performance, product and installation requirements.

2. In addition to the specified and indicated performance and quality requirements, furnish products and perform installation work consistent with the design intent and necessary to the provision of complete operating electrical systems.

1.3 REFERENCES

A. American National Standards Institute (ANSI):

1. C2 - National Electrical Safety Code.

B. National Electrical Contractors Association (NECA):

1. 1 - Standard Practices for Good Workmanship in Electrical Construction

2. 400 – Recommended Practice for Installing and Maintaining Switchboards.

3. 402 – Recommended Practice for Installing and Maintaining Motor Control Centers.

4. 404 - Recommended Practice for Installing Generator Sets.

5. 500 - Recommended Practice for Installing Indoor Commercial Lighting Systems.

C. National Fire Protection Association (NFPA):

1. 70 - National Electrical Code.

1.4 SUBMITTALS

A. General:

1. Submit information substantiating that the products comply with the Contract requirements.

2. Submit Shop Drawings, Product Data, Samples and other specified submittals on a "system" basis. Retain, and assemble drawings and data from manufacturer or component manufacturers such that each submittal is for a complete system.

3. Refer to submittal requirements in related Division 1 sections of the Specifications.

4. Submit information substantiating that the products comply with the specified regulatory, testing, code, and standards requirements; including independent testing agency requirements, such as Underwriters Laboratories Inc., and industry standards organization requirements, such as the National Electrical Manufacturers Association.

5. Develop and submit a curriculum and outline for each training course, for equipment specified.

B. Quality Control Submittals:

1. Submit results of factory tests two weeks prior to product shipment from factory.

2. Submit results of field tests immediately upon completion of the field test.

3. Submit results of the Engineer's field inspections upon completion of inspection.

C. Contract Closeout Submittals:

1. Refer to related Division 1 sections of the Specifications for basic definitions and requirements for record documents.

2. Submit, at the completion of the work, record drawings in the approved electronic format, indicating the actual electrical installation, size and construction details. Include the following information:

a. Lighting layout, type, circuit designation and control, including each conduit and wire as installed.

b. Layout and circuiting for wiring devices, surface raceways and related equipment, including each conduit and wire size.

c. Layout and circuitry for power circuits to mechanical equipment and other electrified building equipment, including each conduit and wire size.

d. Supporting and mounting details.

e. Special systems layouts such as fire alarm, security, lighting control, and telecommunications systems.

f. Panel schedule drawings consisting of each panelboard. Schedules shall indicate the "as built" circuiting with loads and room numbers identified. Room numbers on schedules shall include the architectural room number indicated on the Drawings and the signage room numbers from the signage schedules.

g. Power one-line diagrams shall be provided in a plastic, framed enclosure and mounted in the rooms housing the electrical switchboards.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with the applicable requirements of ANSI C2 and NFPA 70.

a. Requirements of ANSI C2 and NFPA 70 shall be minimum standards of products and installation work. Furnish products and perform installation work which exceeds the standards of ANSI C2 and NFPA 70 when specified or indicated.

2. Comply with applicable requirements of city, county, and state laws, ordinances and regulations including modifications and supplements to ANSI C2 and NFPA 70.

3. Comply with the applicable requirements of U.S. Department of Labor, Occupational Safety and Health Administration Standards (OSHA).

1.6 PROJECT/SITE CONDITIONS

A. Environmental Requirements: Provide products suitable for operation under the following environmental conditions:

1. Temperature: - 0 to 100 degrees F.
2. Humidity: 0 to 95 relative percent, non-condensing.
3. Altitude: 6,000 feet above sea level.
4. Seismic performance category: Seismic Zone 1, IBC Site Classification “C”.

1.7 WARRANTIES

A. Refer to the Conditions of the Contract for provisions concerning Contract general warranty, Statements of Compliance, correction of Work period, and form of Special Warranty.

1.8 MAINTENANCE

A. General:

1. Retain portable and detachable portions of the installation such as tools, tool kits, instruction books, wiring diagrams, service manuals, operating handles and keys until the completion of work.
2. Transmit the above items to the Owner when the work has been accepted and an itemized receipt obtained.

B. Operations and Maintenance Manuals:

1. Prior to final acceptance of Project, and as described in related Division 1 sections of the Specifications furnish and deliver to Owner bound manual(s) of instructions for operation and maintenance of all pieces of equipment and systems furnished under this Division of Specifications.
2. Provide a separate binder(s) for each system.

C. Extra Materials:

1. Furnish keys to the Owner together with any duplicates which may have been made. Securely wire keys for each lock together and plainly tag and mark the keys to indicate the lock number or piece of equipment they operate. Also indicate the physical location of the lock by building name or number, panel number, or room name or number.
2. Provide wiring diagrams, instruction books, installation books, and service manuals to the Owner. Clearly identify each item as to which product it applies and the equipment location.
3. Provide special tools as specified and required for equipment maintenance to the Owner. Clearly identify each item as to which piece of equipment it applies and the equipment location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. General:

1. Furnish products by one of the equipment manufacturers listed under the heading "Manufacturers" within the applicable sections. When given, furnish the specified product model or brand for the selected manufacturer.

2. Provide products, for which quantities of two or more are to be furnished, from the same manufacturer and of the same product or model series.

3. Furnish product components designed to be used together and which are physically and electrically compatible.

B. Product Substitutions: Product substitutions may be requested when the "or as approved" clause is specified under the heading "Manufacturers". Submit product substitutions for approval per related Division 1 sections of the Specifications.

2.2 PRODUCTS

A. Product Listing and Labeling: Provide listed and labeled product for which listings and labelings exist by Underwriters Laboratories Inc. (UL), Factory Mutual (FM), or similar independent testing organizations recognized by the authorities having jurisdiction. For products for which there are no such listings and labelings, provide listed and labeled components of those products, for which component listing and labelings exist.

B. PCB Content Prohibited: Provide products which do not contain any amounts of polychlorinated biphenyl (PCB) compounds.

C. Asbestos Content Prohibited: Provide products which do not contain any amounts of asbestos.

D. Firestop Systems: Provide products suitable for the application as specified in related Division 7 sections of the Specifications.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Permit Architect (and Owner) to observe factory tests. Provide minimum five working days notice of factory tests.

2. Schedule no more than one equipment or system factory test per week.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right of way for piping and conduit installed at required slope.

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 8 sections of the Specifications.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 sections of the Specifications.

3.2 INSTALLATION

A. Common Requirements for Electrical Installation:

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

B. Sleeve Installation for Electrical Penetrations:

1. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors 2 inches above finished floor level.
7. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
    a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 7 sections of the Specifications.
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 7 sections of the Specifications.
11. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe 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.

C. Sleeve-Seal Installation:

1. Install to seal exterior wall penetrations.

2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping: Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7 sections of the Specifications.

E. Wiring Installation:

1. Install wiring for control systems, power feeder and branch circuits, lighting branch circuits, communication and auxiliary systems, such as fire alarm and security, in separate raceways unless otherwise indicated.

2. Install power system wiring for Emergency systems in separate raceways.

3. Run equipment grounding conductor in all raceways.

F. Device Location: Allow for relocation prior to installation of wiring devices and other control devices, for example, receptacles, switches, occupancy sensors, fire alarm devices and access control devices, within a 10-foot radius of indicated location without additional cost.

G. Wet, Damp, or Dry Location Work: Provide products as appropriate for wet, damp, or dry locations as defined by NFPA 70.

H. Hazardous Locations Work: Provide products in classified, hazardous locations per NFPA 70 as indicated on Plans.

I. Manufacturer Installation Instructions: Install equipment in accordance with the manufacturer's installation instructions and recommendations.

J. Field Painting:

1. Refer to related Division 9 sections of the Specifications for prime and finish field-painting requirements.

2. In a manner satisfactory to the Owner, touch-up or refinish factory-applied paints or finishes which are chipped, defaced, scratched, or in any other way disturbed due to handling, installation, or general construction work.

K. Personnel Protection From Suspended Work: Where suspended equipment, piping or ductwork or any of their supporting or reinforcing members extend 7 feet or less above the floor or any other walking surface, cover all edges, projecting surfaces and sharp corners with pre-fabricated soft rubber pads, elastomeric insulation, caps or equivalent to prevent injury to personnel.

3.3 FIELD QUALITY CONTROL

A. Field Tests:

1. Permit Architect (and Owner) to observe field tests. Provide minimum three working days notice of field test.

2. Schedule tests in coordination with other Contract work. Schedule no more than one equipment or system field test per day.

B. Electrical Inspections

1. Permit Architect/Engineer to observe inspections. Provide minimum of three working days of notice to Owner and/or Engineer of electrical inspections.

2. Schedule inspections in coordination with other Contract work. Schedule no more than one equipment or system inspection per day.

3. Provide additional rough and intermediate inspections as requested by Owner.

4. Comply with all inspection requirements for equipment and construction per NREL's Lab-level procedures for electrical safety.

3.4 TRAINING

A. General:

1. Provide training for Owner's personnel in the operation and maintenance of equipment as specified in the applicable Section of the Specifications for the particular equipment and system.

2. Develop training schedule which is acceptable to the Owner. Submit schedule for approval.

3. Provide instruction books, manuals, and other classroom material required as part of the training sessions.

4. Provide instructors who are certified by the equipment and system manufacturers.

5. Provide training at the Project Site for the Owner's personnel, as specified in related Division 1 sections of the Specifications.

B. Operations and Maintenance Training:

1. Train personnel in all aspects of normal operation of the equipment, including starting, adjustments while running, and shutdown.

   a. Train personnel to recognize incipient problems, including inefficient or dangerous modes of operation, and provide instruction in corrective actions to be taken.

2. Train personnel to perform all recommended maintenance on the equipment.

C. Specialized Repair Training:

1. Provide specialized training for Owner's personnel in repair of equipment as specified in the applicable section of the Specifications for the particular equipment and system.

2. Provide training equal to that given to the respective manufacturer's entry-level repair personnel.

   a. Owner's personnel may take training along with manufacturer's personnel.

3. Test the Owner's personnel, and certify that those who successfully complete this training may perform routing troubleshooting and repair of equipment without altering or voiding the manufacturer's warranty.

END OF SECTION 260500

SECTION 260519
LOW-VOLTAGE ELECTRICAL CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this Section.

1.2 SUMMARY

A. This Section includes the requirements for the power and control cables, instrumentation cables and multi-conductor cable, and wire connections and related devices.

1.3 DEFINITIONS

A. Definitions of terms and other electrical considerations as set forth in the following:

1. National Electrical Code
2. Institute of Electrical and Electronic Engineers
3. Instrument Society of America
4. National Fire Protection Association

1.4 SUBMITTALS

A. Product Data for Wire and Cable, Wire Connections and Related Devices

1.5 QUALITY ASSURANCE

A. Certificates:

1. Deliver conductors to the site in their original unbroken packages or on their original cable reels.
2. Mark or tag all conductor packages and cable reels plainly with UL label, AWG or circular mil size, voltage rating, insulation type, type of stranding, manufacturer's name, trade name and month and year when manufactured.

B. Codes and Standards:

1. ICEA S-61-402: Thermoplastic insulated wire and cable for the transmission and distribution of electrical energy.
2. ICEA S-19-81: Rubber insulated wire and cable for the transmission and distribution of electrical energy.
3. UL 83 for thermoplastic insulated wires.
4. UL 1063 for machine tool wires and cables.
5. UL 758 for 221 deg F appliance wiring materials.
6. Fed Spec. J-C 30A.
7. Shield instrument cable: UL listed as ITC/PLTC in compliance with UL 2250 and UL 13.

C. Provide new conductors manufactured within 1 year of the date of delivery to the site. Store conductors out of the weather and where not subject to damage or deleterious conditions.

D. Assembly and testing of cable shall comply with the applicable requirement of ICEA Publication No. S-68-516. MATERIALS.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Power and Control Cable Manufacturers:

1. Cablec.
2. General Cable.
3. Rome Cable.
4. Okonite.
5. Triangle.
6. American Insulated Wire Corporation.
7. Diamond Wire and Cable.

B. Acceptable Instrumentation Cable Manufacturers:

1. Belden.
2. Carol.
3. Alpha.

2.2 MATERIALS

A. Power and Control Conductors:

1. Unless specifically indicated otherwise, conductor sizes are for soft drawn, minimum 98% conductivity, minimum insulation rating of 600 volts. All wire shall be copper.
2. Except as indicated, provide conductors of No. 12 AWG minimum size.
3. Conductors No 16 AWG and smaller: TFFN insulation, unless otherwise indicated.
4. Conductors No 14 AWG and larger: Stranded with Type THHN/THWN dual rating insulation, unless otherwise indicated
5. Provide conductors with Type THHN/THWN dual rating for No. 14 and No. 12. Provide solid conductors for use on toggle switches and receptacles.
6. Wire No. 10 and smaller shall be factory color-coded.
7. Wire No. 8 and larger shall be color-coded by field painting or color taping the entire length of exposed ends or 12 inches of exposed end, whichever is less.
8. For all sizes, conductors with mineral filled cross-linked thermosetting polyethylene insulation, UL Type XHHW rated 75° C in wet or dry locations, may be used.
9. Where ambient temperatures are within 18°F of the maximum allowable operating temperature of the insulation of a conductor, provide conductors with insulations (such as Type AVA) suitable for the temperatures and other conditions to be encountered.
10. Stranded wire is to be used for all control circuits No. 14 THHN/THWN unless otherwise noted.

11. Use only stranded wire for all motor connections minimum size No. 12 THHN/THWN unless otherwise noted.

12. Solid wire shall be used on all receptacle outlets and toggle switches.

    a. Contractor may use stranded wire on toggle switches and receptacles if all terminations are made with compression type ring tongue terminals.

13. Class B or Class C stranded or solid, annealed, uncoated per UL 83 or 1063.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Techniques:

1. Where a common neutral is run for two or three home run circuits, phase conductors shall be connected to breakers in the panel, which are attached to separate phase legs in order that the neutral conductors will carry only the unbalanced current.

    a. Neutral conductors shall be of the same size as the phase conductors unless specifically noted otherwise.

    b. Receptacle circuits in office areas must have a separate neutral for each phase circuit, common neutrals are not allowed for receptacle circuits in office areas.

2. Install wires only in approved raceways.

3. Pull in wire with an approved wire-pulling lubricant as recommended by cable manufacturer for all wire No. 4 and larger, or where necessary.

    a. Use Ideal "Yellow," EFCOR WGY, polywater, or equal.

    b. Do not use oil, grease or similar substances.

4. Do not install wire in:

    a. Incomplete conduit runs.

    b. Until after the concrete work and plastering is completed.

    c. Until after all moisture is swabbed from conduits.

5. Install and terminate all wire in strict accordance with manufacturer's recommendations.

6. Install all control wiring in accordance with manufacturer's recommendations and control system requirements for complete operating system.

    a. All wires including field and internal panel wires are to be numbered at both ends as per manufacturer's control drawings.

    b. Mark all control wires prior to termination.

7. Strip insulation in a manner that voids the nicking of wires.

8. Install instrumentation cables in separate raceway systems and not with power cables.

9. Provide all wiring and equipment for heating, air conditioning and ventilation systems, and telephone and security systems.

10. Before installing conductor, remove debris and moisture from conduit and equipment enclosures.
11. All control lines are to be continuous with no splices. Keep splices to a minimum on power circuits.
12. All shielded cables are to be continuous with no splices between instrument element and controller.
13. Solid conductors shall be terminated at equipment terminal screws with proper care that the conductor is tightly wound around the screw.
    a. The conductor will not protrude beyond the screw head.
14. Stranded conductors shall be terminated directly on equipment box lugs making sure that all conductor strands are confined within the lug.
15. Use ring type lugs where equipment box lugs have not been provided.
16. Conductors No. 1-gage and smaller shall be hand pulled. Larger conductors may be installed using power wire pulling winches.
17. Minimum power wire size to be No 12 unless otherwise indicated.
18. Minimum control wire size to be No 14 unless otherwise indicated.

B. Cabling: Neatly arrange and lace conductors in switchboards, panel boards, gutters and terminal cabinets by means of:
   1. T&B "Ty-Rap" ties
   2. Panduit Wire Ties
   3. Approved equal

C. Color Coding:
   1. The following color code shall be followed for all 208/120-volt systems.
      a. Phase A - Black
      b. Phase B - Red
      c. Phase C - Blue
      d. Neutral - White
      e. High Phase or Wild Leg - Orange
      f. Equipment Ground - Green
   2. The following color code shall be followed for all 480/277 volt systems:
      a. Phase A - Brown
      b. Phase B - Orange
      c. Phase C - Yellow
      d. Neutral - Gray
      e. Equipment Ground - Green
   3. All 120 volt control wiring shall be violet for power and white for neutral.

4. Color shall be integral with the jacket material.
5. General-purpose D.C. control circuits shall be light blue for negative, pink for positive.
6. Switch legs shall be violet.
7. Color coding and phasing shall be consistent throughout the site.
    a. Bus bars at panel boards, switchboards, and motor control centers shall be connected A-B-C, top to bottom, or left to right, facing connecting lugs.

D. Splices:
1. Splices in 600-volt wire, which are not pre-insulated, shall be insulated with four layers of tape each half-lapped.
2. Splices in below grade pull boxes or in any box subject to flooding shall be made watertight using either:
    a. A heat shrink insulating system listed for submersible applications.
    b. An epoxy resin splicing kit.

E. Control Connections:
1. Connect control wiring as indicated and in accordance with the wiring diagrams furnished by the equipment manufacturer
2. Number all wires in accordance with control wiring diagram at each end of the wire.
3. Use insulated ring type wire terminators for connections to all screw terminals manufactured by:
    a. T-B Stakon
    b. 3M & Corp.
    c. Or approved equal
4. CONTRACTOR is responsible for working from manufacturer's drawings for process equipment connections

F. Firestopping: Apply Firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire resistance of assembly. Coordinate with the requirements related Division 7 sections of the Specifications.

3.2 FIELD QUALITY CONTROL

A. Test: Perform meggar tests in conformance with related Division 26 Sections of the Specifications.

3.3 SCHEDULES

A. General Installation Sequence:
1. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry.
2. Number all wires at each end after being installed in the conduit and prior to meggar testing and termination.
3. Meggar all wires prior to final connection of devices.

END OF SECTION 260519

SECTION 260526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this Section.

1.2 SUMMARY

A. This Section includes:

1. Methods and materials for grounding systems and equipment.

1.3 DEFINITIONS

A. Definitions: Definitions of terms and other electrical considerations as set forth in the:

1. National Electrical Code.
2. Institute of Electrical and Electronic Engineers.
3. Instrument Society of America.
4. National Fire Protection Association.

1.4 SUBMITTALS

A. Furnish complete submittals for all components of the grounding system and testing in conformance with Division 1 requirements.

B. Contractor shall submit a written grounding test plan and resume for the individual who will perform the grounding tests detailing experience and qualifications. Contractor shall submit blank test result forms prior to testing.

1.5 QUALITY ASSURANCE

A. Electrical components, devices and accessories, listed and labeled as defined in NFPA 70, Article 100.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Components as manufactured by:

1. Copperweld
2. Blackburn
3. Weaver
4. Burndy
5. Thomas and Betts

2.2 MATERIALS

A. Equipment Grounding Circuit Conductor:

1. This conductor shall be the same type and insulation as the load circuit conductors. The minimum size shall be as outlined in Table 250-95 of the National Electrical Code, unless shown otherwise on the drawings.

2. Shall be present in all raceways. The conduit system is not an allowable equipment ground.

B. Use of salts, water or compounds to attain the specified ground resistance is not acceptable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:

1. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.

2. Provide a separate grounding conductor for each motor and connect at motor box. Do not use bolts securing motor box to frame or cover for grounding connectors.

3. Size grounding and bonding systems in accordance with the NEC.

4. Route inside raceway.

5. Provide a green insulated wire-grounding jumper from the device ground screw to a box grounding screw or for grounding type devices and to equipment grounding conductor.

3.2 FIELD QUALITY CONTROL

A. Test in accordance with applicable Division 26 sections of the Specifications.

END OF SECTION 260526

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SECTION 260529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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 SUMMARY

A. This Section includes:

1. Provide supports, anchors, sleeves, seals and other related supporting devices and methods as specified and indicated.

2. Refer to related Division 26, 27 and 28 Specification sections of the Specifications for specific and supplemental supporting device requirements.

1.3 SUBMITTALS

A. General: Submit specific details for supporting electrical equipment with the appropriate electrical equipment submittal.

B. Product Data: Submit manufacturer's technical product data on supporting devices specified and indicated.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. Firms regularly engaged in the manufacture of supporting devices, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.

PART 2 - PRODUCTS

2.1 MANUFACTURED SUPPORTING DEVICES

A. U-channel Strut Systems:

1. Manufacturers

a. Cooper B-Line, Inc.

b. Hilti Corp.

c. Midland-Ross Corp.

d. Unistrut Corp.

2. No. 12 gage, hot-dipped galvanized steel, with 9/16-inch diameter holes, 8-inches on center on top surface, with manufacturer's standard, natural/neutral finish.

3. Provide corrosion-resistant fittings which mate and match the U-channel.

B. Wall and Floor Conduit Seals:

1. Manufacturers

a. O-Z/Gedney Co., Unit of EGS Electrical Group

2. Provide factory-assembled, watertight wall and floor seals, of types and sizes required, suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls.

3. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.

C. Conduit Straps:

1. Galvanized steel.

D. Clevis Hangers:

1. Galvanized steel with 1/2-inch diameter hole for round steel rod.

E. C-Clamps:

1. Black malleable iron, 1/2-inch rod size, approximately 70 pounds per 100 units.

F. Miscellaneous Devices and Hardware:

1. Corrosion resistant.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.3 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, conduit may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum

static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.4 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 5 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.5 PAINTING

A. Touchup:

1. 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. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
2. Touchup: Comply with requirements in related Division 9 Sections of the Specifications for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this Section.

1.2 SUMMARY

A. This Section includes provision of conduit, wireways, fittings, boxes, and associated accessories.

1.3 REFERENCES

A. American National Standards Institute (ANSI)

1. C80.1 - Specification for Rigid Steel Conduit, Zinc Coated
2. C80.3 - Specification for Electrical Metallic Tubing, Zinc Coated
3. C80.5 - Specification for Rigid Aluminum Conduit
4. C80.6 - Intermediate Metal Conduit (IMC) - Zinc Coated

B. Federal Specifications (Fed. Spec.)

1. QQ-P-416F - Plating, Cadmium (Electrodeposited)

C. National Electrical Manufacturers Association (NEMA)

1. TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
2. TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing
3. TC 6 - PVC and ABS Plastic Utilities Duct for Underground Installation
4. TC 9 - Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation

D. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code

E. Underwriters Laboratories Inc. (UL)

1. 1 - Flexible Metal Conduit
2. 6 - Rigid Metal Conduit
3. 360 - Liquid-Tight Flexible Steel Conduit
4. 514A - Metallic Outlet Boxes
5. 514B - Fittings for Conduit and Outlet Boxes
6. 651 - Schedule 40 and 80 Rigid PVC Conduit
7. 797 - Electrical Metallic Tubing
8. 870 - Wireways, Auxiliary Gutters, and Associated Fittings
9. 886 - Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
10. 1242 - Intermediate Metal Conduit

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for each type of conduit, fitting, wireway, box, and accessory provided.

B. Shop Drawings: Submit dimensioned drawings indicating generic connections to electrical panels and other equipment.

1.5 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. Comply with NFPA 70.

C. Provide only new conduit. Unless otherwise indicated, provide conduits for all types of conductors or cables of all systems and voltage levels.

D. Conduit sizes not indicated on the drawings shall be in accordance with NEC requirements and shall be sized based on quantities and sizes of wire installed there in.

1. Increase conduit size as required to conform to the mandatory grounding conductor, installed therein.

a. Grounding conductor mandatory in all raceways.

b. Size as an insulated additional conductor.

E. Conduit types not specified shall be consistent with other conduit systems in the area, the area classifications and enclosure requirements.

F. All material shall comply with standard FS WW-C-581E:

1. Conduit, metal rigid, and intermediate

2. Coupling, elbow, and nipple

3. Electrical Conduit: Steel, zinc coated

G. Rigid Steel Conduit, Zinc Coated: Shall conform to the following applicable specifications for rigid ferrous metal conduit.

1. ANSI C80.1

2. UL 6

3. CSA C22.2 No.45

H. Electric Metallic Steel Tubing: Shall conform to the following applicable standards.

1. UL 797

2. ANSI C80.3

I. Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit: Conduit shall conform to the following applicable specifications.

1. Federal SpecificationWW-C-581D

2. ANSI C80.1-1979

3. UL 6

4. CSA C22.2 No.45
5. NEMA Publication RN1-1974 (Type A)
6. NEMA TC2

J. Intermediate Metal Conduit: Shall conform to the following applicable standards.
1. UL 1242
2. ANSI C80.6

K. Electric Plastic Tubing (EPT) and Conduit (EPC40 and EPC80): Shall conform to the following applicable standards.
1. NEMA TC3

L. Electric Nonmetallic Tubing

M. Liquidtight Flexible Metallic Conduit: Shall conform to the following applicable standards.
1. UL 360

N. Rigid Plastic Conduit: The conduit shall conform to the following standards.
1. UL 691
2. NEMA TC2
3. Fed Spec. WC-1094A.

O. Each piece of conduit shall bear a UL Label.

PART 2 - PRODUCTS

2.1 RIGID STEEL CONDUIT (RSC)

A. Manufacturers:
1. Allied Tube & Conduit Corp.
   a. Kwik-Couple conduit may be used in lieu of separate couplings.
2. LTV Steel Tubular Products Co.
3. Midwest Electric Products, Inc.
4. Wheatland Tube Co.

B. Conduit: Rigid, heavy wall, hot-dipped galvanized steel threaded type, per UL 6 and ANSI C80.1.

2.2 INTERMEDIATE METAL CONDUIT (IMC)

A. Manufacturers:
1. Allied Tube & Conduit Corp.
   a. Kwik-Couple conduit may be used in lieu of separate couplings.
2. LTV Steel Tubular Products Co.
3. Midwest Electric Div. Products, Inc.
4. Wheatland Tube Co.

B. Conduit: Rigid, intermediate grade, hot-dipped galvanized steel, threaded both ends, per UL 1242 and ANSI C80.6.

2.3 CONDUIT FITTINGS FOR RSC AND IMC

A. Manufacturers:

1. Adalet Div., Scott Fetzer Co.
2. Allied Tube and Conduit Corp.
3. Appleton Electric Co., Inc.
4. Midwest Electric Products, Inc.
5. O-Z/Gedney Unit, EGS Electrical Group
6. RACO, Subsidiary of Hubbell Inc.
7. Thomas & Betts Corp.
8. Wheatland Tube Co.

B. Fittings: Cast or malleable iron, cadmium- or zinc-plated, per UL 514B, with tapered threaded hubs and screw attached, stamped metal covers or screw attached, heavy cast metal with gaskets as needed for the installation.

C. Expansion Fittings: Cast or malleable iron, with threaded hubs, metallic pressure packing and copper grounding jumper, allowing a minimum of two inches of conduit movement.

D. Hazardous Location Fittings: Cast or malleable iron, cadmium - or zinc-plated, per UL 886, with tapered threaded hubs and plugs, and filling spouts with drain valves for vertical conduits, as needed for the installation.

E. Locknuts: Malleable iron or steel, zinc- or cadmium-plated.

F. Bushings: For conduit sizes 1 inch and smaller, provide flame-retardant, insulating, grounding type; for sizes greater than 1 inch, provide malleable iron or steel, zinc- or cadmium-plated, grounding type with insulating insert, molded and locked into bushing edge.

2.4 ELECTRICAL METALLIC TUBING (EMT)

A. Manufacturers:

1. Allied Tube & Conduit Corp.
    a. Kwik-Fit conduit may be used for sizes approved for set-screw fittings.
2. LTV Steel Tubular Products Co.
3. Midwest Electric Products, Inc.
4. RACO, Subsidiary of Hubbell Inc.
5. Wheatland Tube Co.

B. Tubing: Zinc-coated steel tubing per UL 797 and ANSI C80.3

2.5 FITTINGS FOR EMT

A. Manufacturers:

1. ETP Unit, EGS Electrical Group
2. Midwest Electric Products, Inc.

3. O-Z./Gedney Unit, EGS Electrical Group

4. RACO, Subsidiary of Hubbell Inc.

B. Fittings: Zinc-plated steel, pressure-connection compression-type, per UL 514B. Indenter types are not acceptable. Set-screw types may be used on conduit sized 2 inches or larger only.

2.6 FLEXIBLE STEEL CONDUIT

A. Manufacturers:

1. Electri-Flex Co.

2. Triangle PWC, Inc.

B. Conduit: Continuous, spirally wound, interlocked zinc-coated strip steel, per UL 1.

2.7 FITTINGS FOR FLEXIBLE STEEL CONDUIT

A. Manufacturers:

1. Electri-Flex Co.

2. American Electric: Steel City/Thomas & Betts.

B. Fittings: Malleable iron or steel, zinc- or cadmium-plated, threadless hinged clamp type female end and threaded male end with locknut. Set-screw securing type is not acceptable.

2.8 LIQUID-TIGHT FLEXIBLE STEEL CONDUIT

A. Manufacturers:

1. AFC Cable Systems, Inc.

2. Anamet Inc.: Sealtite

3. Electri-Flex Co.

B. Conduit: Same as flexible steel conduit except with liquid-tight jacket of flexible polyvinyl chloride per UL 360.

2.9 FITTINGS FOR LIQUID-TIGHT FLEXIBLE STEEL CONDUIT

A. Manufacturers:

1. AFC Cable Systems, Inc.

2. Appleton Electric Co.

3. Crouse-Hinds Div., Cooper Industries, Inc.

4. Hubbell, Inc.

5. Killark, Subsidiary of Hubbell, Inc.

6. O-Z/Gedney Unit, EGS Electrical Group

7. RACO, Subsidiary of Hubbell, Inc.

8. Thomas & Betts Corp.

B. Fittings: Malleable iron or steel, zinc-or cadmium-plated, with compression type steel ferrule and neoprene gasket sealing rings with insulated throat. Provide liquid-tight connection.

2.10 RIGID NON-METALLIC CONDUIT AND FITTINGS

A. Manufacturers:

1. Carlon
2. Certainteed Corp.
3. LCP Chemicals & Plastics, Inc.

B. Conduit: Schedule 40, rated for 90°C. Conductors, polyvinyl chloride suitable for direct burial and normal above ground use, per UL 651 and NEMA TC 2.

C. Fittings: Polyvinyl chloride to mate and match to conduit type and material per NEMA TC 3.

2.11 WIREWAYS

A. Manufacturers:

1. Cooper B-Line Inc.
2. Hoffman Enclosures, Inc. (NEMA 1, 3R, 12, EMI/RFI-tight)
3. Queen Products Co. (EMI/RFI-tight wireway only)
4. Pico Metal Prod. (EMI/RFI-tight wireway only)
5. Square D Co. (NEMA 1, 3R, 12)

B. Lay-in Wireway (NEMA 1):

1. Provide enclosed, square or rectangular-section steel raceway, per UL 870, with full length hinged cover with latch and provisions for screw-down fastening. Provide knockouts on bottom and sides for full length. Provide corrosion-resistant phosphate primer and light gray baked enamel finish.
2. Provide connectors, end closures, and related items to mate and match the type and material of the wireway. Provide connectors suitable for lay-in of wires and cables.

C. Raintight Lay-In Wireway (NEMA 3R): Same as lay-in wireway except with knockouts on bottom only and cover gasketing.

D. Oil-Tight Wireway (NEMA 12): Same as lay-in wireway except with oil-resistant gaskets and without knockouts.

E. EMI/RFI-Tight Wireway:

1. Provide EMI/RFI-tight wireway with a shielding effectiveness of 70 dB for magnetic fields in the 150 kHz to 200 kHz frequency range and 100 dB for electric and plane wave fields in the range of 200 kHz to 10 gHz frequency range.
2. Provide wireways of sizes indicated and constructed of 14 gage steel and 10 gage steel on end flanges.
3. Provide full length cover, hinged on one side and screw fastened on the other, or screw clamp fastened on both sides. Provide stainless steel clamps and full length rolled wireway lip.
4. Provide cadmium-plated finish, per Fed. Spec. QQ-P-416C, Type II Class 2.
5. Provide full length, combination woven-plated steel mesh and oil-resistant gasketing.

2.12 BOXES

A. Acceptable Manufacturers:

1. Metal Boxes
2. Steel City
3. Appleton
4. Crouse Hinds
5. Approved equal

B. Plastic and/or fiberglass boxes.

1. Hoffman
2. Carlon
3. Approved equal

C. Sheet Steel Outlet Boxes:

1. Provide galvanized, minimum no. 14 gage, sheet steel boxes with knockout openings, extensions, adapters, plaster rings, and like items as required for installation.
2. Match accessories to box gage and finish unless specified or indicated otherwise.

D. Cast or Malleable Iron Outlet Boxes:

1. Provide galvanized or cadmium plated boxes with tapered threaded hubs, adapters, cover plates, and like items as required for application.
2. Provide accessories to match box material and finish, galvanized or cadmium-plated unless specified or indicated otherwise.
3. Provide gaskets for installations in wet locations.

E. Junction and Pull Boxes:

1. Provide boxes smaller than 5 inches square that conform to outlet box requirements.
2. Provide boxes greater than 5 inches square of galvanized sheet steel, full seam welded with bent-in flanges seam welded at corner joints, machine screw fastened cover of equal or greater gage as box.
3. Provide cover gasketing and number of knockouts as required for installation. Secure gasketing to box.

F. Conduit Bodies: Provide galvanized, cast-metal, threaded-conduit-entrance ends, removable cast or galvanized steel covers and corrosion-resistant screws.

G. Floor Boxes: Provide watertight, cast iron floor boxes with corrosion-resistant finish, shallow-type, with four 19 mm (3/4-inch) threaded conduit hubs, box and cover adjustment assemblies and screw type cover.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUIT

A. General:

1. Provide conduit sized per NFPA 70 requirements unless larger sizes are specified or indicated. Do not install conduit smaller than 3/4 inch.
2. Install conduits a minimum of 12 inches (free air space) from steam and hot water pipes and other sources of heat and a minimum of 3 inches (free air space) from other mechanical piping.
3. Do not install conduit across pipe shafts, vent duct openings, hatchways and other openings. Install conduit to avoid conflicts with mechanical ductwork and piping.
4. Do not install conduit within the flutes of metal roof deck.
5. Do not install conduit in roof insulation system or similar construction.
6. Do not install conduit in setting beds and similar construction intended as a base for a finished floor material such as terrazzo.
7. Install conduit so as not to damage or run through structural members. Provide sleeves for conduit runs through structural walls.
8. Provide bushings on ends of conduit or box connectors except at couplings and threaded type fittings, boxes and hubs.
9. Provide gasketed, heavy cast construction fittings outdoors and in wet or damp locations.

B. Conduit Type:

1. Install EMT for wiring 600 volts and below for the following:
   a. Concealed dry locations.
   b. Exposed dry locations except for the areas listed below.
2. Install flexible steel conduit in dry locations, for the following:
   a. Concealed in movable partitions.
   b. Connections to lighting fixtures, maximum length of 6 feet.
   c. Connections to dry-type distribution transformers, maximum length of 6 feet.
   d. Connection to equipment subject to vibration or movement, such as motors, maximum length of 6 feet.
   e. Below access floors.
3. Install liquid-tight, flexible steel conduit for the following:
   a. Exterior locations.
   b. Wet or damp locations.
   c. Where corrosive vapors are present.
   d. Where subjected to water, oil or other liquids.
   e. Liquid-tight flexible steel conduit may be installed for flexible steel conduit conditions.
   f. Liquid-tight flexible steel conduit may be installed in exterior locations and wet or damp locations in lieu of rigid steel conduit.

4. Install plastic duct and rigid non-metallic conduit in accordance with the following:
    a. Underground applications only, unless otherwise noted.
5. Rigid Metal Conduit:
    a. Use rigid metal conduit or intermediate metallic conduit
        1) Where legally required,
        2) Where exposed to the weather
        3) Where located in unheated areas
        4) Where subject to mechanical injury,
        5) Where defined as exposed conduit less than 10 feet above the floor in areas accessible to anyone other than authorized operating or maintenance personnel.
6. Corrosive Areas:
    a. Use conduit system as indicated on the drawing.
        1) Rigid plastic conduit where conduit can be adequately supported and free from possibility of mechanical damage.
        2) P.V.C. jacked rigid steel conduit where conduit may need to be self-supporting or where subject to mechanical damage.
        3) Use liquid tight flexible conduits.
            a) Connections shall be corrosion-resistant PVC jacketed consisting of a bonded 40 mil thick PVC coating on the metal connector, with an extended PVC throat to form a seal around the liquid tight conduit, connectors to have an insulated throat and integral neoprene sealing ring.
            b) As manufactured by Thomas & Betts 3300.
        4) Galvanized rigid conduit where area and conduit are to be painted using an epoxy based paint.

C. Exposed Conduit:
1. Install conduit exposed in spaces as follows:
    a. Equipment rooms of masonry or concrete construction for mechanical or electrical equipment.
    b. Storage, shipping and receiving rooms of masonry or concrete construction without ceilings.
2. Install conduit so as not to damage or run through structural members.
3. Install exposed conduits in neat symmetrical lines parallel to the center lines of the building construction.
4. Install exposed conduit work to avoid interference with ceiling inserts, ceiling lights, ventilation outlets and building equipment and systems.
5. Install horizontal runs above bottom of building trusses, joists or similar structural members.
6. Install conduit on the web or inside flange, but not on the outside face, of exposed columns.

7. Install conduits entering surface mounted equipment offset to parallel the wall as required for the equipment served.

8. Install vertical and horizontal runs of conduits in groups on common supports, whenever possible.

D. Concealed Conduit

1. Install conduit concealed above ceilings and in walls unless otherwise specified or indicated.

2. Do not install conduit in floors except to serve floor boxes.

3. Install conduit under concrete slab for floors-on-grade.

4. Install concealed conduit above hung ceilings in accordance with exposed conduit requirements.

E. Supporting and Hanging Conduit:

1. Do not support conduit from pipes, hangers, or extension of installation work of other building trades.

2. Support horizontal conduit 1 inch size and smaller at 6 ft. - 0 in. maximum.

3. Support horizontal conduit greater than 1 inch size at 8 ft. - 0 in. maximum.

4. Support vertical conduit 1-1/4-inch size and smaller at 8 ft. - 0 in. maximum.

5. Support vertical conduit greater than 1-1/4-inch size support at 10 ft. - 0 in. maximum.

6. Support single conduit runs with galvanized ring bolt type hangers with specialty spring clips; do not use plumbers perforated straps or malleable galvanized iron straps.

7. Support multiple conduit runs with trapeze-type, hot-dipped galvanized steel hangers, galvanized steel conduit straps and minimum 1/2-inch galvanized threaded support rods. Provide 20 percent spare capacity.

8. Install conduit to prevent sagging and formation of water traps.

9. Support conduits on both sides of bends.

F. Connections, Fittings and Couplings:

1. Provide expansion fittings in conduit runs which cross building expansion joints, are mechanically attached to separate structures, or have lengths exceeding 200 feet.

2. Fasten conduit terminations in sheet metal enclosures by two locknuts, and terminate with bushing. Install locknuts inside and outside enclosure.

3. Where conduit joints occur in concrete slabs, damp or wet locations or exposed to weather, ensure that joints are mechanically tight and sealed against the entrance of water by using a coating of thread lubricant.

4. Provide solvent-welded joints for plastic conduit.

G. Sleeves and Openings:

1. Provide watertight pipe curb assemblies for multiple conduits or pipe seal assembles for single conduits where conduits pass through roof or waterproofing membranes. Do not use pitchpockets.

2. Provide sleeves for conduits which passes through openings cut through wall and floors of gypsum board, masonry or concrete. Grout around sleeves and conduits.

H. Cleaning Conduits: Clean conduits thoroughly and dry inner surfaces before wires and cables are installed. Clean, or replace conduits found to be plugged or dirty.

I. Cutting and Bending Conduits:

1. Cut conduits straight, properly ream, and cut threads for RSC deep and clean. Running threads are not permitted.

2. Field bend conduit with benders designed for the purpose so as not to distort or vary internal diameter.

3. Apply a suitable protective coating where protective galvanized coating has been destroyed or damaged by cutting or threading.

J. Spare Conduits:

1. Provide nylon pulling rope, minimum 1/8-inch diameter, in conduits indicated or specified as spare or empty. Provide one 3 feet of slack, in addition to rope the length of each conduit.

2. Seal spare and empty conduits with a conduit cap or plug to which the pulling rope is attached.

K. Identification: Provide conduit markers for the following power wiring conduits with the specified lettering at a 10-foot spacing and on every box:

1. Emergency power system: "Emergency"

2. Uninterruptible power supply system: "UPS"

3.2 INSTALLATION OF WIREWAY

A. General:

1. Install wireway system complete with fittings and accessories.

2. Install expansion fittings where wireways cross building expansion joints.

B. Identification

3.3 INSTALLATION OF BOXES

A. General:

1. Provide cast iron outlet boxes for surface mounted conditions and in outdoor, damp or wet locations.

2. Provide cast iron outlet boxes for devices indicated or specified as weatherproof.

3. Provide boxes without knockouts and with cover gaskets for outdoor, damp or wet locations.

4. Use outlet boxes not less than 4 inches square and 2-1/8 inches deep.

5. Avoid installation of outlet boxes in unsuitable locations, such as a moulding or a break in wall finish.

6. Install recessed outlet boxes in finished walls to bring box edge flush with or not more than 1/4 inch back of finished surface.

7. Locate outlet boxes as indicated on plans, except as indicated on interior elevation, when given.

8. Offset outlet boxes, indicated as back-to-back on a common wall, horizontally so as to maintain acoustical isolation between adjacent rooms. Provide 24 inches minimum spacing.

9. Non-metallic boxes may be used in wet or corrosive locations. Boxes shall be NEMA 4X constructed of fiberglass polyester.

B. Fastening:

1. Fasten outlet boxes in furred ceilings rigidly to the supporting structure.

2. Install boxes on exposed columns within the web space without penetrating the structural member and mounted so that face of outlet box does not project beyond the column flanges.

3. Install boxes plumb and square with building lines.

4. Install boxes independent of conduit.

C. Identification

3.4 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Coordinate with the requirements of Division 7 of the Specifications.

END OF SECTION 260533

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SECTION 260553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

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 SUMMARY

A. This Section includes electrical identification work for the following:

1. Electrical power, control, and communication conductors.
2. Operational instructions and warnings.
3. Danger signs.
4. Equipment/system identification signs.

1.3 REFERENCES

A. Applicable Standards: Comply with the applicable requirements of the following standards.

1. National Fire Protection Association (NFPA): 70 - National Electrical Code (NEC), as applicable to installation of identifying labels and markers for wiring and equipment.
2. Underwriters Laboratories (UL), pertaining to electrical identification systems: 969 - Marking and Labeling Systems.

1.4 SUBMITTALS

A. Submit in conformance with Division 1 sections of the Specifications.

B. Includes, but not limited to: Product Data: Submit manufacturer's data on electrical identification materials and products.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:

1. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application.
2. Where more than single type is specified for an application, selection is Subcontractor option, but provide single selection for each application.

B. Color-Coded Equipment and J-Box Markers:

1. General: Self-adhesive vinyl tape not less than 3 mils thick. Provide 2-1/4-inch wide by 9-inch long marker.
2. Colors: Provide orange tape, unless otherwise indicated or required by governing regulations.

C. Cable/Conductor Identification Bands:

1. General:
   a. Vinyl-cloth self-adhesive cable/conductor markers of wrap-around type

b. Prenumbered plastic coated type

c. Numbered to show circuit identification number.

D. Plasticized Tags:

1. General:

a. Preprinted or partially preprinted accident-prevention and operational tags,

b. On plasticized card stock with matt finish suitable for writing,

c. Approximately 3-1/4" x 5-5/8", with brass grommets and wire fasteners

d. With appropriate preprinted wording, including large-size primary wording, e.g., "DANGER, CAUTION, DO NOT OPERATE."

E. Self-Adhesive Plastic Signs;

1. General:

a. Self-adhesive or pressure-sensitive, preprinted, flexible vinyl signs for operational instructions or warnings.

b. Sizes suitable for application areas and adequate for visibility.

c. Proper wording for each application, e.g., "EXHAUST FAN."

2. Colors: Provide white signs with black lettering, unless otherwise indicated or required by governing regulations,

F. Engraved Plastic-Laminate Nameplates:

1. General:

a. Engraving stock melamine plastic laminate nameplate in sizes (minimum height of characters shall be 1/8 inch) and thicknesses specified or indicated,

b. Engraved with block letter style of sizes and wording indicated

c. Black face and white core plies (letter color) except as otherwise indicated,

d. Punched for mechanical fastening: Except where adhesive mounting is necessary because of surface it is mounted to.

e. Thickness:

1) 1/16-inch, for units up to 20 square inches or 8-inch length

2) 1/8-inch for larger units.

f. Fasteners:

1) Self-tapping stainless steel screws

2) Except contact-type permanent adhesive where screws cannot or should not penetrate mounting surface.

2. Red face and white core plies (letter color) nameplates shall identify Standby Power and Uninterruptible Power Supply (UPS) sources.

G. Labels

1. Embossed tape shall not be permitted for any application.

2. Use "Kroy" type or approved equivalent type of permanent labeling for the receptacles, switches, and device boxes: Letter size to be a minimum size of 3/8 tape with 3/16" letter.

3. Normal power color is Blue letters on White background.

4. Stand-by power color is Red letters on White background.

5. Mechanical equipment is Black letters on White background

H. Wire Markers

1. All conductors including field conductors and internal panel conductors are to be permanently marked with wire numbers at each end.

2. Wire numbers are to correspond to the wire numbers on the control drawings, or panel and circuit numbers for receptacles and lighting.

3. Wire numbers are to correspond to the terminal block number to which they are attached in the control panel.

4. Markers are to consist of machine printed, black characters on white heat-shrinkable tubing.

a. Tubing shall be sized for the wire and insulation on which it is to be placed.

b. Tubing to be shrunk using a heat gun which produces low temperature heated air.

c. Tubing shall be tight on the wire, characters shall face the open panel, characters shall read from left to right or top to bottom.

d. Manufactured by:

1) Raychem.

2) Brady.

e. Wire marker shall start within 1/32" of end of stripped insulation point.

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. General Installation Requirements:

1. Install electrical identification products as indicated, in accordance with manufacturer's written instructions and requirements of NEC.

2. Coordination: Where identification is to be applied to surfaces, which require finish painting, install identification after completion of painting.

3. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.

B. Cable/Conductor Identification:

1. General:

a. Apply cable/conductor identification, including circuit number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present.

b. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.

C. Operational Identification and Warnings:

1. General:

a. Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems, and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install self-adhesive plastic signs or similar equivalent identification, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures.

b. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.

D. Danger Signs:

1. General: In addition to installation of danger signs specified, indicated, and required by governing regulations and authorities, install appropriate danger signs at locations indicated and at locations subsequently identified by Subcontractor of electrical work as constituting similar dangers for persons in or about project.

2. Higher Voltage: Install danger signs (with actual circuit voltage) on all building doors, switchboards, panelboards switches, circuit breakers, etc., wherever it is possible (under any circumstances) for persons to come into contact with electrical voltages to ground greater than 277V.

3. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons or damage to or loss of property.

E. Equipment/System Identification:

1. General:

a. Install engraved plastic-laminated nameplates on each major unit of electrical equipment in the building; including central or master unit of each electrical system including communication/control/signal/alarm systems, unless unit is specified with its own self-explanatory identification or signal system.

b. Except as otherwise indicated, provide single line of text, 1/2-inch high lettering on 1-1/2-inch high sign (2 inches high were two lines are required), black lettering on white field.

c. Provide text matching terminology and numbering of the contract documents and shop drawings.

d. Sign shall indicate unit designation, normal source circuit number ("Fed from..."), circuit voltage, and other data specifically indicated.

2. Switchboards, panelboards, electrical cabinets, and enclosures.

a. An Example of a panelboard identifier tag would be:

1) 1L5 (Panelboard identifier)

2) Fed from 1PPL (Power Source identifier)

b. Access panel/doors to electrical facilities.

c. Disconnect switch.

d. Push buttons, selector switches, indicating lights. (Circuit number and voltage not required on sign).

e. Transformers. (Include primary voltage, secondary voltage, and number of phases.)

f. Power generating units.

g. Fire alarm control panel.

h. Uninterruptible power supplies (UPS).

i. Wireway used as auxiliary gutter tap locations with circuit number of circuit being tapped.

j. Provide on outside of wireway.

3. Provide "EMERGENCY" conduit markers on all conduit and pullboxes that contain these conductors.

4. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment.

5. Secure the identification to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.

F. Device Plates

1. Receptacles shall be marked with serving panel and circuit number.

2. Switches used to control exhaust fans or other equipment shall identify load controlled.

3. Switches used for controlling lighting, identify lighting controlled, mark with serving panel and circuit number.

G. Junction Box Identification

1. All junction boxes shall be identified as to circuits contained within the junction box.

2. Junctions boxes in the standby power system shall be painted blue.

3. Junction boxes for the security system shall be painted yellow.

4. Junctions boxes in the fire alarm system shall be painted red.

3.2 EXAMPLES

A. The CONTRACTOR shall coordinate the wire numbering system with all vendors or equipment so that each and every wire has a unique wire number associated with it for the entire system, and not just that of the local panels.

1. Wires on a common terminal shall have the same wire number assigned.

2. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment.

a. It is intended that the cable number will form a part of the individual wire number.

b. All individual control conductors and instrumentation cable shall be identified at pull points as described above.

3. The instrumentation cable numbers shall incorporate the loop numbers shown.
4. Motor power conductors:
    a. The first part of the number shall be the motor's tag number prefixed by the letter M.
    b. The second part shall be the starter's load terminal number.
        1) Example: Wire marker number - M100-T1
            a) M - Motor
            b) 100 - Motor tag number
            c) T1 - Starter's load terminal number for Phase A
5. Motor control conductor:
    a. The first part of the number shall be the motor's tag number prefixed by the letter M.
    b. If the hot wire for the control circuitry is from a control circuit transformer, the second part of the marker number for the hot wire shall be L.
    c. If the hot wire for the control circuitry is from a circuit breaker panelboard, the second part of the marker number for the hot wire shall be H.
    d. The second part of the number for the neutral conductor shall be N.
    e. Except for the green color identification, ground wires shall not have wire markers.
    f. The second part of the number for the remainder of the motor control circuit numbers shall be identified by a series of consecutive numbers.
        1) Example: Motor control circuit wire number - M100 - H
            a) M - Motor
            b) 100 - Motor tag number
            c) H - Control power obtained from circuit breaker panelboard
        2) Example: Wire marker number - M100 - 7
            a) M - Motor
            b) 100 - Motor tag number
            c) 7 - The seventh consecutive connection in the control circuit
    g. Wire markers numbers for the portion of the control circuit that controls more than one motor shall indicate all motors controlled.
        1) Example: Wire marker number - M101/102/103 - H
            a) M - Motor
            b) 101/102/103 - Motors 101, 102, 103 control circuits are powered from a common source.
            c) H - Control power obtained from circuit breaker panelboard
6. Instrument and control conductors.
    a. The first part of the number shall be the instrument or control loop tag number prefixed by the letter L.

b. If the prime power for the loop is 120 VAC, the second part of the tag number for the power wiring shall be H or N for Hot or Neutral, respectively.

c. If the prime power is DC (such as 24 VDC), the second part of the tag number for the power wiring shall be P or M for Plus or Minus, respectively.

d. The second part of the number shall be from a series of consecutive numbers starting with 1.

1) Example: Wire marker number - L212 - 11

a) L - Instrument or control loop

b) 212 - Loop Number

c) 11 - The eleventh consecutive connection in the control loop

7. Shielded instrument cable.

a. Each instrument cable (2 or 3 conductor) which has individual conductors of No. 16 AWG or smaller shall have wire markers placed on the cables outer jacket only.

b. The individual conductors shall not be marked.

c. The first part of the number shall be the instrument for control loop number prefixed by L.

d. The second part of the number shall be from a series of consecutive numbers and prefixed by C.

1) Example: Wire marker number - L212 - C3

a) L - Instrument or control loop

b) 212 - Loop number

c) C - Cable

d) 3 - The third consecutive cable in the loop

B. All spare conductors shall be terminated on terminal screws and shall be identified with a unique number as well as with destination.

1. Example: Wire marker number - S212-11

a. S - Spare

b. 212 - Loop number

c. 11 - The 11th consecutive spare in the control loop

C. CONTRACTOR as part of the Record Drawing requirements shall update the conduit schedule to reflect the exact wire numbers and destination points for all wires including spares.

END OF SECTION 260553

SECTION 260800
ELECTRICAL SYSTEMS COMMISSIONING

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 DESCRIPTION

A. This Section includes the Contractor's responsibilities and participation in the commissioning process for Divisions 26, 27, and 28.

B. Management of the commissioning process is primarily the responsibility of the Commissioning Agent (CA), with support for start-up, testing, and commissioning the responsibility of the Divisions 26, 27 and 28 Contractors. The commissioning process does not relieve this Contractor from participation in the process, or diminish the role and obligations of this Contractor to complete all portions of work in a satisfactory and fully operational manner.

C. Work of Divisions 26, 27 and 28 include, but are not limited to:

1. Coordination with, and participation of the Lighting Controls Contractor with CA.
2. Notification to the CA of any system performance issues that arise or are identified during construction, that may modify or effect final system performance, configuration, or sequence of operation.
3. Submit an equipment start-up plan with forms that will be used to record start-up.
4. Perform testing and start-up of the electrical equipment (2 weeks notification to be given to CA.)
5. Complete pre-functional test checklists.
6. Provide qualified personnel to perform functional testing, and to verify equipment/system performance.
7. Provide equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements. Provide fine-tuning or trouble-shooting of system performance if either of these measures becomes necessary.
8. Provide operation and maintenance information and as-built drawings to the General Contractor for review, verification and organization, prior to distribution. The CA will review these documents. Incorporate review comments by CA, owner and design team.
9. Provide assistance to the CA to develop, edit, and document system operation descriptions.
10. Coordinate training for the systems specified in this Division with the CA. Prior to training, provide an agenda and sample materials to the CA for review.
11. It is the responsibility of the contractor to verify that systems are complete and ready for testing. If any functional performance test or part of a test fails and requires retesting, the CA will be compensated by the contractor for the retesting effort at the CA's standard billing rates.
12. Attend Commissioning meetings.

D. Work of the Lighting Control Contractor:

1. Notify the CA of any system performance issues that arise or are identified during construction or checkout of the system prior to functionally testing.
2. Provide CA with controls diagrams, hardware specifications and sequences of operations, at least 12 weeks prior to the scheduled start of functional testing.
3. Complete pre-functional test checklists.
4. Participate in start-up and testing.
5. Demonstrate point-to-point testing at the request of the CA.
6. Perform functional testing of the controls system.
7. Participate in fine-tuning or troubleshooting of system performance if either of these measures becomes necessary.
8. Provide O&M information and as-built drawings to the General Contractor for verification, organization and distribution. Incorporate review comments by CA, owner and design team.
9. Provide training for the Lighting Controls systems. Prior to training, provide a training agenda and sample materials to the CA for review.
10. Attend commissioning meetings as requested by the CA.

1.3 RELATED WORK

A. All testing and start-up procedures and documentation requirements specified within Division 1, and Divisions 26, 27 and 28 related portions of this project.

B. Commissioning procedures that require participation of Divisions 26, 27 and 28 Contractors.

C. Allow sufficient time before final completion dates so electrical systems start-up, checkout, and commissioning testing can be accomplished.

D. For specified electrical systems and component testing by a third-party testing Contractor, coordinate with the CA, the scope and schedule of that testing for observation by the CA during the actual testing.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Contractor shall provide all standard and specialized test equipment as necessary to test and start up and functionally test the electrical equipment. Equipment subject to calibration shall be calibrated per NETA, ISA, and manufacturer's requirements, whichever is the most stringent.

B. Proprietary test equipment required to test installed equipment, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, and demonstrate its use and assist the contractor and CA in the commissioning process.

PART 3 - EXECUTION

3.1 WORK PRIOR TO COMMISSIONING

A. Complete all phases of work so the system can be energized, started, tested, and otherwise commissioned. The Divisions 26, 27 and 28 Contractors have primary start-up responsibilities with obligations to provide, install and test complete systems, including all sub-systems so they

are functional. This includes the complete installation of all equipment, materials, raceways, wire, terminations, controls, etc., per the Contract Documents and related directives, clarifications, change orders, etc.

B. The commissioning plan, developed by the CA, is an attachment to these specifications. Upon request of the CA, this Contractor shall provide assistance and consultation in updating the plan to reflect actual installed equipment. If system modifications or clarifications are incorporated to this and related sections of work, commissioning of this work will be made at no additional cost to the Owner. If Contractor-initiated system changes have been made that alter the commissioning process, the CA will notify the Architect, and the Contractor may be obligated to compensate the CA to test the revised product.

C. Specific pre-commissioning responsibilities of Divisions 26, 27 and 28 include, but are not limited to the following:

1. Normal start-up services required to bring each system into a fully operational state. This includes motor rotational check, cleaning, lug tightening, control sequences of operation, etc. The CA will not begin the commissioning process until each system is complete, including normal contractor start-up and debugging.

2. The Contractor shall complete pre-functional checklists for and functional testing of the equipment and systems to be commissioned as described in the Commissioning Plan including, but not limited to the systems shown below:

a. Lighting control systems

3. Factory start-up services will be provided for key equipment and systems specified in Divisions 26, 27 and 28. This Contractor shall coordinate this work with the manufacturer and the CA.

D. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems and/or sub-systems, if expediting this work is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Contractor. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start-up, debug, and functionally test all systems within the division of work. These same technicians shall be made available to assist the CA in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested by the CA and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System problems and discrepancies may require additional technician time, CA time, redesign and/or reconstruction of systems, and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

C. The CA reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the CA to get the job done. A liaison or intermediary between the CA and qualified factory representatives does not constitute the availability of a qualified technician for purposes of this work.

3.3 WORK TO RESOLVE DEFICIENCIES

A. In some systems, misadjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Architect, with input from the Contractor, equipment supplier, and CA. Whereas all members will have input and the opportunity to discuss, debate, and work out problems, the Owner's Representative will have final jurisdiction on the necessary work to be done to achieve performance.

B. Corrective work shall be completed within the allotted time on the construction schedule. Experimentation to correct system performance will be permitted. If the CA deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the CA will notify the Architect/Engineer indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Divisions 26, 27 and 28 Contractor's responsibility.

3.4 ADDITIONAL COMMISSIONING

A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers, and CA shall include a reasonable time reserve to complete this work as part of their standard contractual obligations.

3.5 RECOMMISIONING

A. After the initial and peak seasoning commissioning is completed, there may be additional work required to serve new or revised loads. This work is not part of the contract.

3.6 TRAINING

A. This Contractor will be required to participate in the training of the Owner's engineering and maintenance staff for each mechanical system and the related components as described in other sections of these specifications. Training will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment.

B. Training will be conducted jointly with the CA, the design engineers, the equipment vendors, and the Contractor. The Division 26, 27 and 28 Contractors will be responsible for the generic training, as well as instructing the Owner's staff on the system peculiarities specific to this project.

3.7 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two sets. Divisions 26, 27 and 28 as-built drawings shall include updated architectural floor plans, and the individual electrical systems in relation to actual building layout.

B. Maintain as-built red-lines on the job site as required in Division 1. Given the size and complexity of this project, red-lining of the drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining and/or posting of drawings is considered essential and mandatory.

C. In addition to the stated requirements for operation and maintenance data, provide one copy of equipment technical literature, operation and maintenance literature, and shop drawings to the CA as soon as they are available. This requirement is for review of these documents prior to distribution of multiple copies for the Owner's final use.

END OF SECTION 260913

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SECTION 260923
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this Section.

1.2 SUMMARY

A. This Section includes distributed microprocessor-driven relay-based lighting control panels and local relay-based relaty controllers; photoelectric sensors, vacancy/occupancy sensors, and low-voltage control switches / button stations.

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 specification sections. Any submitted device that differs in any manner from that specified must be marked "exception." Clearly indicate exact differences and include all manufacturers data as indicated.

B. Product data including device operation, warranty period, wiring diagram(s), dimensions, materials, and finishes.

C. Samples: Where specifically required in the specifications, submit samples for devices and device plates for color selection and evaluation of technical features.

D. Test Reports: All required testing reports and certificates shall be submitted to the Contracting Officer for approval prior to project acceptance.

E. Maintenance data for all lighting control devices shall be included in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain lighting control devices from a single source with total responsibility for compatibility of lighting control system components specified in this section and related Division 26 sections of the Specifications.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use and installation conditions by a testing agency acceptable to authorities having jurisdiction.

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate features of devices specified in this section with systems and components specified in other sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with related Division 26 sections of the Specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following: Manufacturers indicated are used to establish a minimum acceptable standard of quality. Similar products by comparable manufacturers will be considered.

1. Distributed microprocessor-driven relay-based lighting control panels and local relay-based relaty controllers:

   a. Eaton Corporation; Greengate Lighting Controls

   b. Legrand Corporation; Wattstopper Lighting Controls

   c. Acuity Brands; LC&D Lighting Controls

   f. or approved equal

2.

3. Photoelectric Sensors:

   c. Match same manufacturer as the microprocessor-driven lighting control system.

4. Vacancy/Occupancy Sensors: Wall Switch

   a. Eaton Corporation; Greengate Lighting Controls

   b. Legrand Corporation; Wattstopper Lighting Controls

   c. Acuity Brands; LC&D Lighting Controls

   f. or approved equal

5. Vacancy/Occupancy Sensors: Ceiling-mount

   a. Eaton Corporation; Greengate Lighting Controls

   b. Legrand Corporation; Wattstopper Lighting Controls

   c. Acuity Brands; LC&D Lighting Controls

   f. or approved equal

B. Colors: Device and coverplate colors shall be selected by Contract Officer unless otherwise noted.

2.2 GENERAL LIGHTING CONTROL DEVICE REQUIREMENTS

A. Line-voltage Surge Protection: Include in all 120- and 277-volt solid-state equipment. Comply with UL 1449 and with ANSI C62.41 for Category A locations.

2.3 TIME SWITCHES

A. Description: Digital or electronic control type complying with UL 917.

1. Astronomic dial

2. Two-channel

3. Seven-day programming, 365-day microprocessor to provide special or holiday programming

4. Daylight savings

5. Battery back-up

6. Manual override

2.4 PHOTOELECTRIC RELAYS

A. Description: Solid state, with single-pole, single-throw dry contacts rated to operate connected relay or contactor coils or microprocessor input, and complying with UL 773A.

B. Light-level Monitoring Range: 0 to 3500 fc (0 to 37 673 lx), with an adjustment for turn-on/turn-off levels.

C. Time Delay: Minimum 15-second adjustable time delay to prevent false switching.

D. Indoor Ceiling- or Wall-mounting Units: Adjustable for turn-on/turn-off levels, semiflush, calibrated to detect adequacy of daylighting in perimeter locations, and arranged to turn artificial illumination on and off to suit varying intensities of available daylighting.

E. Outdoor Sealed Units: Weathertight housing, resistant to high temperatures and equipped with sun-glare shield and ice preventer.

2.5 OCCUPANCY SENSORS

[A.] Ceiling-mounting Units: Unit receives control power from a separately mounted auxiliary power and control unit, and operates power switching contacts in that unit.

[A.] Ceiling-mounting Units: Unit receives 24V dc power from a remote source and, on sensing occupancy, closes contacts that provide signal input to a remote microprocessor-based lighting control system.

B. Switch-Box-Mounting Units: Unit receives power directly from the switch leg of the 120- or 277-VAC circuit it controls and operates integral power switching contacts rated 800W at 120-VAC, and 1,200W at 277-VAC, minimum.

C. Operation: Turns lights on when room or covered area is occupied and off when unoccupied, unless otherwise indicated.

1. Time Delay for Turning Lights Off: Adjustable over a range from 1 to 30 minutes, minimum.
2. Manual Override Switch: Turns lights off manually regardless of elapsed time delay.
3. Ambient-Light-Level Control: Adjustable for setting a level of ambient illumination above which sensor will not turn lights on when occupancy is sensed.
4. Isolated Relay Contact: Operates on detection of occupancy or vacancy, as indicated, to activate an independent function.
5. Suitable for control of the load type (incandescent, low-voltage, or fluorescent), load capacity, and branch circuit voltage of the lighting fixtures controlled.

D. Auxiliary Power and Control Units: As follows:

1. Relays rated for a minimum of 20-amp normal ballast load or 13-amp tungsten filament or high-inrush ballast load.
2. Sensor Power Supply: Rated to supply the number of connected sensors.

[E.] Passive-Infrared Type: Detects occupancy by a combination of heat and movement in zone of coverage. Each sensor detects occupancy in the sensor's zone of coverage by detecting occurrence of 6-inch (150-mm) minimum movement of any portion of a human body that presents a minimum target of 36 square inches (232 square cm) to the sensor.

[E.] Daylight Filter: Passive-infrared sensor shall incorporate daylight filter to minimize affects of visible light interference.

[E.] Ultrasonic Type: Emits a beam of ultrasonic energy and detects occupancy through use of Doppler's principle in discerning movement in zone of coverage by sensing a change in pattern of reflected ultrasonic energy.

[E.] Dual-Technology Type: Uses a combination of passive-infrared and ultrasonic detection methods to distinguish between occupied and unoccupied conditions for area covered. Particular technology or combination of technologies that controls each function (on or off) is selectable in the field by operating controls on unit.

2.6

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment level and plumb and according to manufacturer's written instructions.

B. It shall be the Contractor's responsibility to locate and aim sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations. Rooms shall have 90 to 100 percent coverage to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room(s). The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with sensors.

C. It is the Contractor's responsibility to arrange a pre-installation meeting with the manufacturer's factory-authorized representative, at the Owner's facility, to verify placement of sensors and installation criteria.

D. Set time delay for all occupancy sensors to maximum 30 minutes.

E. Set Dual-Technology occupancy sensors to be activated by either infrared or ultrasonic technologies.

F. Mount lighting control devices according to manufacturer's written instructions and requirements in related Division 26 Sections

G. Mounting heights indicated are to bottom of unit for suspended devices and to center of unit for wall-mounting devices.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in related Division 26 sections.

B. Wiring Method: Install all wiring in raceway as specified in related Division 26 sections

C. Bundle, train, and support wiring in enclosures

D. Ground equipment

E. Connections: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to related Division 26 sections.

3.4 FIELD QUALITY CONTROL

A. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.

B. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.

C. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.

D. Verify settings of photoelectric devices with photometer calibrated within previous six months.

E. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:

1. Continuity tests of circuits

2. Operational Tests: Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions. Include testing of devices under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

F. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

G. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

H. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.5 CLEANING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.6 DEMONSTRATION

A. Coordinate with training for low-voltage, programmable lighting control system specified in related Division 26 sections.

B. Engage a factory authorized service representative to train the Owner's maintenance personnel as specified below:

1. Train the Owner's maintenance personnel on troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of three hours' training.

2. Training Aid: Use the approved final version of maintenance manuals as a training aid.

3. Schedule training with the Contracting Officer with at least two weeks advance notice.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested, to adjust light levels, make program changes, and adjust sensors and controls to suit actual conditions.

END OF SECTION 260923

SECTION 262416
PANELBOARDS

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 SUMMARY

A. This Section includes provision of new circuit Breakers for pre-existing lighting and appliance branch-circuit panelboards, as specified and indicated.

1.3 REFERENCES

A. American National Standards Institute, Inc. (ANSI)

1. NECA 407 – Recommended Practice for Installing and Maintaining Panelboards.

B. National Electrical Manufacturers Association (NEMA)

1. AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
2. KS 1 - Enclosed Switches.
3. PB 1 - Panelboards

C. Underwriters Laboratories Inc. (UL)

1. 50 - Enclosures for Electrical Equipment.
2. 67 - Panelboards.
3. 98 - Enclosed and Dead-Front Switches.
4. 489 - Molded-Case Circuit Breakers and Circuit-Breaker Enclosures.
5. 869A - Reference Standard for Service Equipment.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for each type of circuit breaker provided.

B. Quality Control Submittals: Submit results of specified field tests.

PART 2 - PRODUCTS

2.1 LIGHTING AND RECEPTACLE PANELBOARDS

A. Manufacturers: Match existing panelboard manufacturer(s).

B. Circuit Breakers:

1. Provide circuit breakers, of size and type required to match existing breakers within panelboards, which comply with NEMA AB 1 and UL 489.
2.
3.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Identification:

1. Coordinate with “Electrical Identification” requirements of related Division 26 sections.
2. Typewrite the load fed by each circuit on a new panelboard directory card.

3.2 FIELD QUALITY CONTROL

A. Field Tests:

1. Operate main and branch devices to insure proper mechanical operation.
2. Verify proper connection of wire terminations.

END OF SECTION 262416

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SECTION 262726
WIRING DEVICES AND MISCELLANEOUS EQUIPMENT

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 SUMMARY

A. This Section includes: wiring devices and device cover plates.

1.3 REFERENCES

A. Federal Specifications (Fed. Spec.):

1. W-C-596F/GEN - Connector, Electrical Power

B. National Electrical Manufacturers Association (NEMA):

1. FB 11 - Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations.
2. WD 1 - General Requirements Wiring Devices.
3. WD 6 - Wiring Devices - Dimensional Requirements.

C. Underwriters Laboratories Inc. (UL):

1. 5 - Surface Metal Raceways and Fittings.
2. 20 - General-Use Snap Switches.
3. 498 - Attachment Plugs and Receptacles.
4. 943 - Ground-Fault Circuit Interrupters.
5. 1054 - Special-Use Switches.
6. 1472 – Solid-State Dimming Controls.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical Product Data on wiring devices and equipment specified and indicated. Submit samples as requested for review.

B. Field Quality Control Test Reports

C. Operation and Maintenance Data: Include manufacturer's instruction manuals and packing label warnings.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm regularly engaged in the manufacture of wiring devices and equipment, of type and sizes specified and indicated, whose products have been in satisfactory use in similar services for not less than five years.

B. Regulatory Requirements:

1. Provide wiring devices per NEMA WD 1 and WD 6.
2. Provide wiring devices per UL 20, 498, and 1472.
3. Provide wiring devices per Fed. Spec. W-C-596F.

PART 2 - PRODUCTS

2.1 WALL SWITCHES

A. Wall Switch - General Purpose:

1. Heavy-duty construction, totally enclosed, thermoset material, construction base and cover, quiet type toggle handle, rated 120-277 volts AC and 20 amperes, silver alloy contacts, equipped with insulated mounting yoke, plaster ears, side and rear wiring terminals, and ground wire terminal.
2. Provide one-pole, two-pole, three-way, and four-way switches as indicated.
3. Devices shall be brown everywhere except in finished areas, where they shall be ivory.
4. The catalog number given for one device is indicative of the quality and features desired for devices of that king.
5. Manufacturers:
    a. Arrow Hart Div., Cooper Industries: 1991-I series.
    b. Hubbell, Inc.
    c. Pass & Seymour Inc.

2.2 RECEPTACLES

A. Duplex Receptacle - General Purpose:

1. Full gang size, heavy-duty, polarized, duplex, parallel blade, U-grounding slot, with green hexagonal equipment ground screw, ground terminals and poles internally connected to mounting yoke.
2. Provide backwiring by a screw actuated clamp and side-wiring screw terminals.
3. Provide 20 ampere, 125 volt, 2-pole, 3-wire rating with NEMA 5-20R configuration.
4. Devices shall be brown everywhere except in finished rooms where they shall be ivory.
5. The Catalog numbers given for one device is indicative of the quality and features desired for devices of that kind.
6. Manufacturers:
    a. G.E. 4107
    b. Hubbell, Inc.
    c. Pass & Seymour, Inc.
    d. Leviton

B. Duplex Receptacle - Ground Fault Circuit Interrupter Type (GFCI):

1. Identical to general purpose duplex receptacle except with solid-state ground-fault sensing and circuit interrupter, Class A, Group 1, per UL 943-2003, and five milliamperes ground-fault trip level.
2. Provide "feed-through" type capable of protecting connected downstream receptacles on a single circuit.
3. Provide device with integral diagnostic indication for miswiring (i.e. line/load reversal).

4. Provide shallow depth design to permit installation in a 2-3/4-inch-deep outlet box.
5. Manufacturers:
    a. G.E.
    b. Hubbell, Inc.: GF5362 series
    c. Leviton Mfg. Co.

C. Duplex Receptacle – Weatherproof:
1. Duplex, 20 ampere, 125 volt, 2-pole, 3-wire, NEMA 5-20R, with cast aluminum lift coverplate.
2. Refer to General Purpose Duplex Receptacle Manufacturers for receptacle series.
3. Coverplate Manufacturers
    a. Hubbell, Inc.: 5206WO (horizontal duplex)
    b. Hubbell Inc.: WPFS26 (vertical, GFCI receptacle)

D. Duplex Receptacle - Isolated Ground:
1. Identical to general purpose, duplex receptacles except with integral insulating barrier between the grounding circuit and screw, and the mounting strap; orange with visible UL/CSA triangle isolating ground identification.
2. Manufacturers:
    a. G.E.: GE5262-C
    b. Hubbell, Inc.
    c. Pass & Seymour

2.3 TELECOMMUNICATIONS OUTLETS

A. General: Coordinate with the requirements of Division 27.

2.4 WIRING DEVICE PLATES

A. Manufacturers: Same as wiring device manufacturer.

B. Plates:
1. Provide wall plates for single and combination wiring devices, of types, sizes, ganging and cutouts, as required for associated wiring devices.
2. Provide plates which mate to the type of wiring device to which they attach.
3. Provide plates with metal screws, colored to match plate finish, for securing plates to devices.
4. Provide wallplates with the following material and finishes, unless otherwise specified.
    a. Field painted plates: steel plate with wrinkled finish and baked-on insulating enamel.
    b. In laboratories, unless otherwise noted on the drawings, 0.04-inch-thick, type 302 or 304, satin finished, stainless steel.
    c. In non-laboratories, unless otherwise noted on the drawings, plastic, smooth thermoplastic, color to match device.
5. Weatherproof plate: corrosion-resistant finish, cast metal with spring-loaded gasketed doors.

6. Provide plates for flush, wall-mounted devices with beveled, smooth rolled outer edge.

7. Provide plates for surface-mounted device boxes with beveled steel, pressure formed for smooth edge fit to box.

2.5 SURFACE METAL RACEWAY

A. Manufacturers:

1. Mono-Systems, Inc.

2. Airey-Thompson Co. (Aluminum only)

3. The Wiremold Co.

B. General: Two-piece, steel construction with factory-applied, grey baked enamel finish], with devices, junction fittings and other matching accessories as required for a complete system and per UL 5.

C. Surface Raceway: Two-compartment, with full-length divider, with devices circuiting, and dimensions as indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Install devices, used with concealed conduit systems, in single or multiple gang flush-mounted outlet boxes. Provide pressed steel boxes with gang plates, unless otherwise specified or indicated.

2. Install devices, used with exposed conduit systems, in single or double gang type "FS" or "FD" cast metal boxes.

3. Install devices and wall plate flush and level.

B. Plates:

1. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceiling, and on surface mounted outlets.

2. Install wall plates after wall finish painting work is completed.

C. Surface Metal Raceway:

1. Mount raceway plumb and level.

2. Maintain grounding continuity between raceway components to provide a continuous grounding path.

3. Install raceway after finish painting work on mounting surfaces is completed.

D. Identification: Comply with requirements of related Division 26 sections.

END OF SECTION 262726

SECTION 265100
INTERIOR LIGHTING

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 SUMMARY

A. This Section includes complete and satisfactorily operating lighting systems, of type and ratings specified and indicated, including lamps, ballasts, and accessories.

B. The specifications augment and elaborate on the lighting fixture schedule, notes and other details on the drawings.

1.3 DEFINITIONS

A. Luminaire: Complete lighting fixture, including ballast housing if provided.

B. LED: Light Emitting Diode

C. CRI: Color-rendering index

1.4 REFERENCES

A. Aluminum Association (AA): SAA-46 - Standards for Anodized Architectural Aluminum.

B. American National Standards Institute (ANSI)

1. C78 Series - Physical and Electrical Characteristics of High Intensity Discharge Lamps.
2. C78.1 - Dimensional and Electrical Characteristics of Fluorescent Lamps - Rapid Start Types.
3. C81 Series - Electric Lamp Bases and Holders.
4. C82.1 - Specifications for Fluorescent Lamp Ballasts.
5. C82.4 - Specifications for High-Intensity-Discharge Lamp Ballasts (Multiple Supply Type).

C. American Society for Testing and Materials (ASTM): D788 - Classification System for Poly(Methyl Methacrylate) (PMMA) Molding and Extrusion Compounds.

D. Federal Communications Commission (FCC): FCC Rules and Regulations, Part 18.

E. Illuminating Engineering Society of North America (IES)

1. LM9 - Approved Method for the Electrical and Photometric Measurements of Fluorescent Lamps.
2. LM80 - Approved Method for Measuring Lumen Maintenance of LED Light Sources.
3. LM79 - Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.

F. Institute of Electrical and Electronics Engineers, Inc. (ANSI/IEEE): C62.47 - Guide on Electrostatic Discharge (ESD): Characterization of the ESD Environment.

G. National Electrical Manufacturers Association (NEMA)

1. LE 4 - Recessed Luminaires, Ceiling Compatibility.
2. LE 2 - H-I-D Lighting System Noise Criterion (LS-NC) Ratings.

H. National Fire Protection Association (NFPA)

1. 101 - Life Safety Code.

2. 70 – National Electrical Code

I. Underwriters Laboratories Inc. (UL)

1. 676 - Underwater Lighting Fixtures

1.5 SUBMITTALS

A. General

1. Submit lighting fixture Product Data and Shop Drawings in booklet form with separate sheet(s) for each type of fixture. Assemble sheets in the same fixture type order as used in this Section, with proposed fixtures, lamps, ballasts, finishes, and accessories indicated on each sheet.

B. Product Data

1. Submit manufacturer's technical product data on interior lighting fixtures and accessories, including the following:

a. Lighting fixtures physical description.

b. Ballasts. (Submit proof of dimming ballast and dimmer compatibility with ballast submittals.)

c. Lamps, including life, output, and energy-efficiency data for lamps.

d. Lenses and louvers.

e. Batteries and chargers.

f. Energy-efficiency data.

C. Shop Drawings

1. Submit dimensioned detail drawings of nonstandard or custom lighting fixtures indicating construction materials, electrical connections, louver and lens assemblies, reflectors and other assembly details and material descriptions.

2. Submit specific mounting and installation details applicable to the proposed installation techniques.

3. Submit details indicating compatibility of each unique lighting fixture and ceiling grid/construction condition. Include proposed ceiling grid/construction products and methods, per Division 9 sections of the Specifications, in the compatibility detail.

4. Power and control wiring diagrams.

D. Photometric Data Submittals

1. Submit a complete photometric report, prepared by an independent testing laboratory.

2. Include the following in the photometric report:

a. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.

b. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.

c. List the measured candela values of the photometric distribution in at least three planes, except in the case of an axially symmetrical lighting fixture. Candela curves, lux (footcandle) and lumen tables, and iso-lux (iso-footcandle) contours are not acceptable.

d. List the type of lamps, ballasts, and lighting control devices, such as lenses and louvers, used with the tested lighting fixture.

E. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:

1. Lamps: Specified units installed.

2. Accessories: Cords and plugs.

F. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.

1. Obtain Contracting Officer's approval of fixtures for mockups before starting installations.

2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

G. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

H. Warranties: Special warranties specified in this Section.

I. Field quality-control test reports.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordination Drawings: Reflected ceiling plan(s) 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. Lighting fixtures.

2. Suspended ceiling components.

3. Structural members to which suspension systems for lighting fixtures will be attached.

4. Other items in finished ceiling including the following:

a. Air outlets and inlets.

b. Speakers.

c. Sprinklers.

d. Smoke and fire detectors.

e. Occupancy sensors.

f. Access panels.

5. Perimeter moldings and soffits.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firm regularly engaged in the manufacture of lighting fixtures of sizes, types and ratings specified, and whose products have been in satisfactory use in similar service for not less than five years.

B. 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.

C. 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.

1.8 WARRANTY

A. 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 Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: 7 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

B. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.

2. Warranty Period for Electromagnetic Ballasts: Three years from date of Substantial Completion.

C. Special Warranty for T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.

1. Warranty Period: One year from date of Substantial Completion.

1.9 MAINTENANCE

A. Extra Materials

1. Provide a quantity of spare fixtures, drivers and lamps, for each type and wattage of luminaire installed, which is no less than the following percentages of installed lamp quantities rounded up to the next whole number:

a. LED luminaires: 10 percent.

b. LED electronic drivers: 10 percent.

c. Emergency self-contained lighting units: 10 percent.

d. Globes and Guards: 10 percent for each type and rating installed.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

A. General

1. Provide recessed lighting fixtures per NEMA LE 4.
2. Provide lighting fixtures specified for ceiling surface mounting with off-set knockouts to avoid interferences with ceiling structure and with knockouts for conduit installation.
3. Provide lighting fixtures UL listed and labeled for the application.
4. Construct lighting fixtures with a minimum number of joints and seams. Fasten unexposed joints by welds, brazing, screws, rivets, or bolts. Weld and file smooth exposed joints. Provide joints and seams completely free from light leaks.
5. Provide cast and extruded lighting fixture components close grained, minimum 3 mm (1/8 inch) thick, and free from imperfections and discolorations. File smooth joints and seams and fit to insure a uniform and smooth joint or seam of uniform surface finish.
6. Securely affix gaskets to metal parts.
7. Provide wiring channels and wireways free from any projections, and any burred, rough, or otherwise sharp edges. Provide points or edges over which conductors pass, which are fully rounded smooth and provided with bushings, sleeves or other similar means of protecting the conductor insulation.
8. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

B. Finish

1. Provide factory-finished lighting fixtures. The use of prepainted metal is not acceptable.
2. Rustproof steel prior to finishing, as a minimum, with a multiple-stage cleaning cycle and iron or zinc phosphate coating with rust inhibitor.
3. Provide exposed natural aluminum surfaces with anodized finish, per Aluminum Association SAA-46 Class 'I'.
4. Finish exposed metal surfaces, including brass, bronze, aluminum except where anodized, nickel, and other similar metals, except stainless steel and chromium-plated metals, with a uniformly thick coat of methacrylate lacquer, transparent epoxy, or other approved clear finish, unless specified otherwise.
5. Provide finishes uniform in quality and free from defects such as scratches, whirls, discolorations, sand and dust spots, cracks, chips and paint runs.
6. Provide lighting fixture housings with finish to match the specified lighting pole finish, unless specified otherwise.

2.2 FLUORESCENT LIGHTING FIXTURES

A. General

1. Provide fluorescent lighting fixtures per NEMA LE 4 and UL 1570.
2. Measure photometric performance of fluorescent lighting fixtures per IES LM41.

3. Construct fixture housing, end plates, lampholder brackets, and lens or louver door frames from minimum no. 20 gage steel or aluminum. Construct latches and hinges from minimum no. 18 gage steel.

4. Provide fixtures complete with lamps, ballasts, and accessories.

5. Locate ballast so that ballast can be removed and replaced without removing the lighting fixture from any normally permanent mounting.

6. Provide interior, light-reflecting surfaces of the fixtures with a minimum reflectance of 85 percent.

7. Provide housings of recessed fixtures with a corrosion-resistant primer and a white methacrylate lacquer, epoxy, or similar finish.

8. Construct lighting fixtures so that the sound level of the complete lighting fixture assembly does not exceed the ballast sound rating by more than two decibels.

9. Provide fluorescent lampholders per UL 542. Provide lighting fixtures which have straight-line fluorescent lamps with premium grade, turn-type, tombstone lampholders unless otherwise specified. Provide lampholders of a type and installed in a manner to prevent high impedance or loose connections between the lamp sockets and lamp contacts.

10. Provide fluorescent open strip lighting fixtures, with lamps mounted below the ballast, with spring-loaded or turret lamp sockets, or other socket locking devices, as approved, to prevent lamps from falling out.

11. Provide starters and starter holders per UL 542.

B. Lenses

1. Acrylic lenses

a. Construct acrylic lenses of 100 percent clear acrylic with a minimum overall thickness of 3 mm (0.125 inch). Provide acrylic lenses which meet or exceed "grade eight" requirements for specific gravity, refractive index, transmittance, deflection, temperature, and tensile strength, per ASTM D788.

C. Construct "Pattern 12" prismatic lenses of 4.8-mm (0.1875-inch), square-based, female cones aligned 45 degrees to the length and width of the panel and with prisms at least 2 mm (0.080 inch) deep.

2.3 GLASS LENSES

A. Manufacture glass lenses of 100 percent clear tempered glass and minimum overall thickness of 3.2 mm (0.125 inch).

2.4 LENSES FOR EMI-SHIELDED FIXTURES

A. Provide "Pattern 12" lenses with integral electromagnetic interference (EMI) shielding for lighting fixtures specified as EMI shielded. Provide low-impedance, conductive connection between the shielding lens, the lens door frame, and the lighting fixture enclosure to insure proper shield grounding.

B. Louvers

1. Parabolic louvers

a. Fabricate parabolic louvers with minimum 0.5-mm-thick (0.02-inch-thick), steel reinforced, semi-specular, low-iridescence, pre-anodized natural aluminum.

b. Fabricate metal louvers from not less than no. 20 gage steel.

c. Fabricate coated plastic louvers from destaticized polystyrene and uncoated plastic louvers from 100 percent acrylic.

2.5 FLUORESCENT LAMPS

A. General

1. Provide fluorescent lamps per ANSI C78.1.

2. Measure life performance of fluorescent lamps per IES LM40.

3. Provide fluorescent lamps with electrical and photometric characteristics per IES LM9.

4. Low-Mercury Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

B. T-8 Rapid-Start High-Output Lamps

1. Provide 265-milliampere rapid start lamps, 44-watt 1200-mm (four-foot) and 25-watt 900-mm (three-foot) lamps with the following characteristics unless otherwise specified:

a. Correlated color temperature: 4400K

b. Minimum average rated life: 24,000 hours

2. Manufacturers

a. GE Company, GE Lighting: Starcoat SPX series

b. Philips Lighting: TL 80 series

c. OSRAM SYLVANIA INC.: Octron 800 series

C. T-5 Linear, Rapid-Start High-Output Lamps

1. Provide rapid-start, 28-watt nominal, 1200 mm (four-foot) lamps with the following characteristics.

a. Correlated color temperature: 4400K

b. Minimum 82 CRI

c. Minimum average rated life: 18,000 hours

2. Manufacturers

a. GE Company, GE Lighting

b. Philips Lighting

c. OSRAM SYLVANIA INC.: Pentran series

D. T-5 Rapid Start, Twin-Tube Lamps

1. Provide 270-milliampere rapid-start, 40-watt nominal, 570 mm (22-1/2 inches) long, lamps with the following characteristics unless otherwise specified:

a. Correlated color temperature: 3000K

2. Manufacturers

a. GE Company, GE Lighting: Biax series

E. Philips Lighting: PL series

F. OSRAM SYLVANIA INC.: Dulux series

2.6 FLUORESCENT LAMP BALLASTS

A. General

1. Factory install fluorescent lamp ballasts in lighting fixtures unless otherwise specified.
2. Provide fluorescent lamp ballasts per ANSI C82.1 and UL 935.
3. Permanently mark ballasts to indicate ballast type designation, date of manufacture, supply voltage and frequency, input current and power, wiring diagram, and quantity, type and wattage of lamps.
4. Provide ballasts suitable for operation at the nominal input voltage as indicated on drawings.
5. Provide ballasts with the lowest sound level rating available for the specified lamp and ballast combination.
6. Provide ballasts capable of starting the specified lamp(s) and suitable for proper operation in the ambient environment in which the ballast is installed.
7. Provide ballasts, for lighting fixtures specified as EMI shielded, with an electromagnetic interference suppression filter which provides a minimum 60 dB attenuation for conducted frequencies greater than 14 kHz.

B. Electronic Ballasts

1. Provide high-frequency electronic energy saving ballasts for dimming operation of T-8 and T-5 lamps, unless otherwise specified.
2. Provide ballasts with the following features and characteristics:
    a. Programmed rapid-start lamp circuitry with integrated circuit design which provides ramp-up heating of lamp electrodes to yield published lamp life of specified lamps.
    b. CBM certified and labeled
    c. Minimum input power factor of 95 percent, lagging.
    d. Lamp operating frequency: greater than 40 kHz.
    e. Internal, automatic, Class "P" ballast thermal protection.
    f. Third harmonic distortion: less than 10 percent of input line current for specified lamp configurations and voltages.
    g. Total harmonic distortion: less than 10 percent of input line current for specified lamp configurations and voltages.
    h. Minimum starting temperature of 10 degrees C (50 degrees F).
    i. Class "A" sound rating.
    j. Minimum ballast factor of 0.92 for T-8 lamps; 1.0 for T-5 lamps.
    k. Maximum lamp current crest factor of 1.7.
    l. Meets IEEE C62.47 Category "A" for transient protection.
    m. Meets FCC Rules and Regulations, part 18, Class "A" for RFI/EMI.
    n. Maximum case temperature of 70 degrees C.

o. End-of-Life circuitry with auto-reset when lamps are changed (T-5 and T-4 lamps).

3. Manufacturers

a. Advance Transformer Company: Mark V series

b. OSRAM SYLVANIA INC.: Quicktronic series

C. Electronic Dimming Ballast

1. Provide high-frequency electronic dimming ballasts for operation of specified lamps and compatible with dimmers and dimming control units.

2. Provide ballasts with the following features and characteristics:

a. CBM certified and labeled.

b. Programmed Rapid start technology.

c. Minimum input power factor of 90 percent at full load and minimum 80 percent at 40 percent output.

d. Lamp operating frequency: greater than 40 kHz.

e. Internal, automatic, Class "P" thermal protection.

f. Class "A" sound rating, throughout dimming range.

g. Meets ANSI C62.41 Category "A" for surge protection.

h. Meets FCC Rules and Regulations, part 18, Class "A" for RFI/EMI.

i. Ballast factor: greater than 0.85 (T-5 and T-8 lamps); greater than 0.95 (T-4 compact lamps); 1.0 (T-5 HO lamps.

j. Constant light output: plus or minus two percent for a line voltage variation of plus or minus 10 percent.

k. End-of-life protection for T-5 and T-5 HO lamps.

l. Capable of striking lamps at any light level without first going to full-light level.

m. Total harmonic distortion: less than 10 percent of input line current for specified lamp configurations and voltages.

n. Ballasts receive signals from a remote controller and through circuitry either for a single ballast or a group of ballasts as indicated, translate the appropriate signal into a corresponding ballast and lamp output. Provide analog control signals.

o. Upon any failure of the analog control signal, ballast produces fully rated continuous output.

p. Lamps operate identically such that the lumen output of lamps connected to the same controller is the same throughout the entire dimming range.

q. Dimming range: 100 percent to 10 percent output.

r. Manufacturers

1) Lutron Electronics Co. Inc.: Hi-Lume series.

2) Advance Transformer Company: Mark X series.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Assemble and install lighting fixtures in a manner to insure a straight and true installation without dents, warps, and other irregularities.
2. Where lighting fixtures are specified or indicated for installation in continuous rows, install fixtures in a continuous end-to-end manner without gaps between fixture segments, and with vertical and horizontal variations, along the length of the continuous installation, no greater than 6 mm (1/4 inch).
3. Coordinate the lighting system installation with relevant trades so as to eliminate installation interferences, such as with hangers, mechanical ducts, sprinklers, piping and steel structure.
4. Install lighting fixtures in a common area space so that the orientation of the lens and louver door latches and hinges are in the same direction.
5. Install dampers or remove dampers and knockouts as required for the specified lighting fixture air-handling capability.
6. Connect wiring according to related Division 26 sections of the Specifications.

B. Mounting and Supporting

1. Rigidly support lighting fixtures, except where specified or indicated for chain, cable, cord hanging, or stem hangers.
2. Support lighting fixtures, installed in suspended grid ceilings, to minimize bowing or deflection of the ceiling system to no greater than 1/360th of the length of the total span of the ceiling member and to not exceed the load capacity of the ceiling system. Provide additional ceiling or lighting fixture supports as required to comply with the above requirements.
    a. Support lighting fixtures independently of the suspended grid ceiling system. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners. Provide support with load capacity as required for lighting fixture, cablings, air boots and other attached loads or 900 N (200 pounds), whichever is greater, with 2.0 safety factor.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
    a. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
4. Provide plaster frames for recessed fixtures installed in other than suspended grid ceiling systems.
5. Install suspended lighting fixtures at mounting heights specified or indicated, plus or minus 6 mm (1/4-inch).
6. Mount lighting fixtures at heights specified and indicated.

C. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Adjust aimable lighting fixtures to provide required light intensities.

E. Light Leaks

1. Assemble and install lighting fixtures to prevent light leaks at any visible ports, seams, and joints of the lighting fixture, which are not designed or intended as lighting output surfaces or areas.
2. Install flush-mounted lighting fixtures to prevent light leaks from between the lighting fixture assembly and the surface in which the lighting fixture is recessed.

F. Identification

1. Provide a neat, visible, permanent red dot marking, nominally 3 mm (1/8 inch) in diameter, on lighting fixtures indicated or specified for life safety lighting. Locate dot on outside corner of the door frame of lighting fixtures with a lens or louver frame, or on the end plate or other suitable and normally visible metal housing of the lighting fixtures without doors. This marking is not required on lighting fixtures expressly dedicated and recognizable for emergency use, such as exit signs.

3.2 FIELD QUALITY CONTROL

A. Field Tests

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
2. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.
3. Conduct burn-in test by operating lighting fixtures between 100 and 120 hours. Replace defective fixtures.
4. Test each lighting fixture and lighting fixture accessory for proper functional and operational performance. Report and immediately correct all deficiencies as they arise. Provide complete documentation of all tests, inspections, and adjustments.

3.3 CLEANING

A. General

1. Clean interior surfaces of lighting fixtures of dirt and construction debris upon completion of installation. Clean fingerprints, smudges, and other marks from lenses, louvers, and reflecting surfaces. Leave free of visible marks.

3.4 ADJUSTING

A. General

1. Upon final completion of the installation of the lighting fixtures and any associated lighting control systems, notify the Contracting Officer in writing to arrange for the final adjustment and aiming of lighting equipment requiring aiming and adjustment.

2. In cooperation with the Contracting Officer, aim and adjust lighting equipment after dark. Provide all necessary experienced labor, tools, and equipment. Provide sufficient sessions for aiming and adjusting until all lighting fixtures and systems are properly aimed and adjusted to achieve the desired lighting effects to the Contracting Officer's satisfaction.

END OF SECTION 265100

SECTION 274100
AUDIO-VISUAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SCOPE OF WORK

A. This section describes the Audio-Visual systems to be installed within the new renovation spaces.

B. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, testing and labeling of all telecommunications infrastructure as described on the Drawings and/or required by these specifications.

1. Furnishing equipment, cabling, supplies, and materials
2. Furnishing labor for installation, testing, software programming, and user training.
3. Third party testing and commissioning
4. Service and maintenance contract
5. All other operations that are not explicitly described herein but are necessary for a complete functioning system which shall adhere to the performance parameters as described on the drawings and/or required by these specifications.

C. Related Sections: The following Sections contain requirements that relate to this Section.

1. Division 26 (Electrical): Power supply, conduit and wiring.
2. Division 27, Section 27 1622, Cabling for Audio-Visual Systems.
3. Division 27, Section 27 4181, Audio-Visual Control Systems.
4. Division 27, Section 27 5213, Projection Screens.

1.03 REFERENCES

A. Underwriters Laboratories Inc. (UL)

1.04 DEFINITIONS

A. Terms:

1. Bidder: Entity generating the bid response.
2. Contractor: Successful Bidder to whom the Owner has awarded the contract.
3. Installer (a.k.a. “Audiovisual Systems Integrator” or similar): Actual entity providing the audiovisual systems installation. Generally equivalent to “Contractor” or else a sub-contractor hired by the Contractor.

4. Furnish: Indicates the responsibility to ship or deliver the item to the job site, freight prepaid, for receipt, staging and installation by others.
5. Install or Installation: Indicates the responsibility of receiving the item at the job site, providing adequate storage, unpacking or uncrating the item, physically securing the item or otherwise making ready the item for its intended use by following the instructions and approved methods of the manufacturer and those contained herein.
6. Provide: Indicates the responsibility to both "Furnish" and "Install."
7. Installation Materials: Shall refer to installed materials which may or may not be explicitly specified herein, but which are essential to a complete functioning system such as the following:

    a. Concealed cabling, exposed and/or loose cabling, cable terminations, cable adapters, cable management, cable labeling, cable dressing, and patch cords (voice, data, audio and/or video)
    b. Custom connection panels and/or blank cover panels for rough-in devices (wall boxes, floor boxes, ceiling boxes, cubbies) or rack-mounted termination/patch fields.
    c. Equipment rack fit-out accessories: Ganging hardware, leveling feet, floor anchors, raised floor pedestals, riser bases, caster bases, doors, locks, side panels, rear panels, top panels, vent blockers, ventilation fans, thermostats, power distribution strips, grounding lugs, grounding bus bars, vertical & horizontal cable lacing bars, rack and/or equipment labels, rack shelves, rack mounts, rack storage drawers, security rack panels, blank rack panels, and rack header identification panels.
    d. Any unmentioned materials as needed to install the systems defined herein.

8. NIC or Not In Contract: Equivalent to "Provided by Others".
9. OFCI or Owner Furnished Contractor Installed: Shall refer to equipment that will be furnished by the Owner for installation by the Contractor. The Contractor shall be responsible for installing and integrating this equipment as detailed herein.
10. The term "shall" is mandatory; the term "will" is informative; and the term "should" is advisory.
11. Format or Aspect Ratio: Proportion of image area expressed as a ratio of width/height.

    a. 4:3 or "NTSC" or "SD" or "SDTV" or "Legacy Video" Format: 1.33:1.
    b. 16:9 or "HD" or "HDTV" Wide Format: 1.78:1.
    c. 16:10 or "Computer" Wide Format: 1.60:1.

B. Acronyms:

1. ADA: Americans with Disabilities Act
2. ALS: Assistive Listening System intended for persons with hearing disabilities
3. AV: Audio-Video or Audio-Visual
4. BGM: Background Music
5. CATV: Community Access Television (aka "cable television")

6. CPU: Central Processing Unit
7. DSP: Digital Signal Processor
8. DVD: Digital Video Disc or Digital Versatile Disc. This acronym refers to the standard optical disc format for playback of audiovisual and/or multi-media.
9. FPD: Flat Panel Display
10. FM: Frequency Modulation. Also refers to the electromagnetic band of frequencies between 88 – 108 MHz used for radio broadcasting within the United States.
11. IP: Internet Protocol
12. IR: Infrared
13. IT: Information Technology
14. LAN: Local Area Network
15. LCD: Liquid Crystal Display, a type of flat panel display
16. MATV: Master Antenna Television
17. PC: Personal Computer. This acronym applies to stationary "tower" or "desktop" workstations, in addition to portable "notebook" or "laptop" computers.
18. PDP: Plasma Display Panel, a type of flat panel display
19. RF: Radio Frequency
20. TO: Telecommunications Outlet – contains one or more service drops for data/voice systems.
21. TV: Television
22. UHF: Ultra High Frequency band of electromagnetic waves, currently 470 – 806 MHz for television broadcasting within the United States.
23. UPS: Uninterruptible Power Supply.
24. USB: Universal Serial Bus, a serial bus standard to interface data devices.
25. VHF: Very High Frequency band of electromagnetic waves, currently 55 – 88 MHz for television broadcasting within the United States.
26. VP: Video Projector
27. WAN: Wide Area Network.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: The following shall be required of the Contractor:

1. The Bidder's installation team members shall hold ALL of the following credentials:
   a. AVIXA CTS-I
   b. AVIXA CTS-D
2. Refer to Specification section 27 4181 for qualifications pertaining to control systems.

1.06 SYSTEM NARRATIVE

A. MEETING ROOM AUDIOVISUAL SYSTEMS:

1. The meeting room AV systems will be provided by the contractor.
2. Sound system:
   a. Audio will be routed through ceiling-mounted loudspeakers.

3. Projection screens
    a. Quantity per drawings
4. Video Projectors
    a. Ceiling-mounted front projector as specified on drawings. Provide ceiling enclosure (drop ceiling conditions) or pole-mounted media enclosure (open-to-structure conditions) for audio amplifier and associated electronics.
5. Motorized projection screens
    a. Motorized projection screens as specified on drawings.
6. Video projectors
    a. Portable front projector as specified on drawings.
7. Equipment racks and audiovisual furnishings:
    a. Racks as noted on drawings.

1.07 DESIGN PRINCIPLES

A. Flexibility: The facility's cable pathway infrastructure (utilized for audiovisual signals, as well as relevant data/voice and AC power signals) shall be sufficiently flexible to allow future expansion of the audiovisual systems. Design parameters for such expansion are in accordance with the Owner's long-term goals and expectations for such systems, as outlined within this section.

B. Cost Effectiveness: The AV systems shall utilize limited resources with utmost efficiency. Emphasis lies on common usability and current technology standards, and not on emerging technology trends or enhanced features.

C. Ease of Operation: The AV systems shall require a minimal amount of Owner training for successful operation. User interfaces (control panels, signal connection panels, etc.) shall have a consistent look and feel throughout the facility.

D. Sustainability: The AV systems shall be designed and installed with a high degree of reliability in mind. Operation of such systems shall require minimal ongoing maintenance, as well as minimal investment by the Owner in dedicated support personnel. It is recommended that the Owner establish an agreement with the AV systems integrator, to secure warranty service calls and/or ongoing maintenance support.

E. Network Connectivity: With the convergence of audiovisual and information technologies, careful planning must occur to ensure that network connectivity is provided for IP-enabled audiovisual devices and systems. Telecommunications outlets and their port quantities must be coordinated to meet or exceed the requirements of the appropriate audiovisual equipment. Discussion with the Owner's IT staff/entity will be required to ensure proper coordination between the audiovisual systems and the network design.

1.08 PERFORMANCE REQUIREMENTS

A. All Audiovisual Systems shall interface and be compatible with each other.

B. Audio

1. Polarity: Absolute signal polarity will be maintained throughout the signal chain such that a positive signal at the input produces a corresponding positive excursion at the loudspeakers.
2. Electronics: The audio system electronics shall deliver the following minimum performance standards as measured from all source inputs for microphones, disc and/or cassette playback devices, etc., through all mixers, audio distribution amplifiers, routers, etc., to all audio signal destinations.

    a. Frequency Response: +/- 0.5dB, 20-20,000 Hz
    b. Hum and Noise: -70 dBu, 20-20,000 Hz, un-weighted
    c. Distortion: 0.1% THD, 20-20,000 Hz

3. Speech Signal: The system shall provide a speech signal in the audience seating area that meets the following requirements:

    a. Frequency response within +/- 3 dB from 500 Hz to 15,000 Hz.
    b. Overall SPL variance of +/- 3 dB.
    c. Measured percentage articulation loss of consonants (Alcons) of 10% or lower.
    d. Maximum average SPL of 87 dB (flat), with 10 dB of undistorted headroom available.

C. Video

1. Electronic Signals: The Contractor shall test the video system to ensure that it passes all possible source resolutions up to UltraHD, and complies with manufacturer's A&E specifications and setup/installation guidelines.

1.09 SUBMITTALS

A. Product Data: For all proposed equipment, cables and connectors, and faceplates for evaluation of technical features. Reference each product to a location on Drawings. Include the following:

1. Manufacturer's submittal sheet (if applicable).
2. Manufacturer's published specification "cut" sheets.
3. Operating characteristics, furnished specialties, and accessories.
4. Physical data (dimensions, weight, line art and/or photos).
5. Test and evaluation data (frequency and phase plots at on-axis and multiple off-axis incidence angles, impedance plot, 1/3-octave polar coverage patterns, etc.)

B. Shop Drawings: The shop drawings listed below are required of the Contractor. Submit all Shop Drawings complete as a single submission. Isolated items will

not be accepted, except with prior approval.

1. System Narrative: Concise narrative description of the system's performance capabilities, physical connection topology, and sequence of operation for each different "scene" or "mode".
2. Schematic: Detailed wiring diagrams showing interconnection of components and products, wiring and cabling diagrams depicting cable types and designators, and device designators. Provide connector designations and terminal strip identification, along with color codes for cables connecting to these devices. Give each component a unique designator and use this designator consistently throughout the project.
3. Diagrams for cable management system – e.g., inside equipment racks, in cable tray, etc.
4. Cabling Schedule: As indicated in Section 27-1622.
5. Mounting Details for Structurally-Rigged "Flown" Loudspeakers in High-Bay Areas: Scaled drawings of complete mounting details, hardware and support surfaces, including details on all load requirements, safety factors, and structural materials.
6. Panels: Scaled drawings of interconnect panels.
7. Equipment & Panel Labels: A list containing the identifier label for all panels and rack mounted equipment. Include information on label type and construction.
8. Equipment Rack Layouts: Fully detailed rack drawings (rack front elevations) indicating equipment orientation within the equipment rack.
9. DSP Functional Diagrams: Complete functional diagrams of all DSP programming and configurations. These diagrams shall utilize functional blocks to graphically depict the routing and processing applied to an audio signal as it passes through the DSP.
10. Cable Routing / Riser Diagram: Diagram showing conduits/pathways for audio and control cabling with clear indications of which cables will be installed in each pathway. Cabling installed in each pathway may be called out via tags on the diagram or via cable run schedule(s) included with the diagram. All cable runs shall be identified with cable ID tags which match those shown on the signal flow diagram described above.
11. Consultant's project documents in electronic format are available to be supplied to the Contractor for their use as part of submittals, provided that the Contractor's submittal does not simply "cut and paste" the Consultant's information without adding the ADDITIONAL information that is outlined in the preceding paragraphs (above); if the Contractor attempts to "cut and paste" the Consultant's information into their submittal without adding the required additional information, the submittal will be rejected in whole.

C. Calculations:

1. Loudspeaker Cabling: Provide calculations for loudspeaker cable sizing based on load impedance, voltage drop, and damping factors.
2. Output Limiters: Provide calculations for proper output compressor/limiter settings in DSP units to prevent loudspeaker damage.

D. Equipment Rack Identification Panel:

1. Within each room containing equipment racks for audio-visual systems, a custom graphical identification panel shall be installed within one (1) of the equipment rack(s) in that room. All equipment rack identification panels in the facility shall be identical.
2. Submit preliminary graphical layout of this panel to the Architect / Engineer for review, included on a USB flash drives using a common digital image format such as JPEG, GIF, TIFF or Bitmap.
3. The panel design shall include the following – no exceptions:
4. Installer's name and contact information
5. Design Engineer's name and contact information
6. Owner's name and a brief description/identifier of the project or system type.
7. The panel shall be mounted in the top rack space unless otherwise indicated on the Drawings.

1.10 CLOSEOUT DOCUMENTATION

A. Operation and Maintenance Data: Complete operating instructions and features available. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:

1. Equipment documentation and instructions.
2. Operating documentation, manuals, and software for equipment and all installed peripherals and features. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware.
3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware
4. System installation and setup guides, with data forms to plan and record options and setup decisions.
5. Quick-reference guides for the installed systems. This includes both touchpanel and general system quick-reference guides.
6. Two (2) USB flash drives with electronic copies of all submittal items listed above. USB flash drives will contain bookmarked PDF files, easily searchable by owner.
7. PDF files on USB flash drives of all submittal items listed above.

B. PDF files on USB flash drives with serial numbers for equipment. List to include the associated manufacturer/ model number and the location of the equipment

C. As-built shop drawings.

1.11 QUALITY ASSURANCE

A. Installer Qualifications: As part of the Bid Response, the Contractor shall furnish evidence of his/her qualifications to perform the work specified. Evidence of Contractor qualifications shall include the following:

1. The Bidder shall clearly identify project team members (Installers) pertaining to the installation of AV systems. Team members to be identified shall be Principal, Project Manager, Chief Engineer, Senior Field Technician, and Software Programmer. The documentation shall include the individual's name, years with firm, and brief resume of the employee's past projects. Resumes shall include a listing of years of experience and any special training, certification by trade associations, and any applicable certification documentation for the proposed system.
2. Due to the complexity of the control & automation system, a manufacturer-certified software programmer shall be required to author the programming component of this project. The Contractor shall include in the Bid Response, the name *and office location* of the manufacturer certified person or entity that will provide programming for the remote control system. The resume shall include a listing of years of experience and include a statement of manufacturer authorization, certification, and qualification.
3. A list of equipment manufacturer product lines, *relevant to the project*, for which the Contractor is authorized as a Distributor, Dealer, and Installer.
4. A list of equipment manufacturer product lines, *relevant to the project*, for which the Contractor is authorized to provide warranty repair service.

B. All provided Installer and Programmer Qualifications (listed above) shall be current and valid at the time of bidding. For example, the Contractor shall not list a product manufacturer or line for which he/she is not a dealer on the bid due date, but for which he/she hopes or intends to become a dealer in the future.

C. Source Limitations: Obtain common materials and equipment through one source from a single manufacturer as much as practical.

D. All equipment for this installation shall be new (packaged in the manufacturer's original packaging), less than one year from the date of manufacture, and without blemish or defect.

E. The Contractor shall maintain the same project manager and field supervisor throughout the installation, and will maintain the same installers.

F. The Contractor shall supply and install any incidental equipment needed in order to result in a complete and operable system without claim for additional payment, even if such equipment is not listed in this Specification.

G. All work related to this Specification shall be completed in a professional manner by fully qualified workers.

H. Reliability: The systems shall be designed to provide professional quality operation over a period of several years without the need for continual maintenance. Equipment that has a high failure rate is not acceptable for installation as part of these systems.

I. Pre-installation meeting: Conduct pre-installation meeting with other trades to:

1. Verify project requirements and manufacturers' instructions
2. Coordinate environmental conditioning of the space (temperature & humidity)
3. Coordinate elements attaching to, penetrating through, or concealed above/behind work in this section.

J. 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.

K. Comply with NFPA 70, "National Electrical Code."

1.12 DELIVERY, STORAGE, AND HANDLING

A. Equipment, Cabling and Installation Materials:

1. Costs of all shipping to the site, and of all unusual storage requirements, shall be borne by the Contractor. It shall be the responsibility of the Contractor to make appropriate arrangements, and to coordinate with the authorized personnel at the site, for the proper acceptance, handling, protections, and storage of equipment so delivered.
2. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F (10 and 30 deg C), and not more than 80 percent relative humidity, non-condensing.
3. Open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.
4. Mark packing list with designations that have been assigned to materials and equipment for recording in the system labeling schedules that are generated by cable and asset management system specified in Part 2.
5. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.
6. Waste Management and Disposal: Separate waste materials for recycling in accordance with Division 01, Section "Construction Waste Management and Disposal".

    a. Remove packaging materials from site and dispose of at appropriate recycling facilities.
    b. Collect and separate for disposal paper, plastic, corrugated cardboard and/or polystyrene packaging materials in appropriate onsite bins for recycling.
    c. Dispose of all non-recyclable packaging materials and debris in a safe and environmentally responsible manner according to the instructions set forth by the General Contractor, local ordinances or codes and the Environmental Protection Agency.

1.13 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

B. Interior, Controlled Environment: System components installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F (2 to 50 deg C) and 20 to 90 percent relative humidity.

1.14 WARRANTY

A. Project Warranty: Refer to Contract Conditions for project warranty provisions.

B. Manufacturer Warranties: Submit to Owner or Owner's Representative all written and dated warranties, in addition to completed product support registration cards, as issued by product manufacturers warranting all individual components against defects in materials or manufacturing, for the periods established by said manufacturers. The start date of the warranties shall be the date of final system acceptance.

C. System Warranty: The Bidding Contractor or sub-contractor (Installer) shall make known, in writing, at time of Bid any exceptions that might exist between conditions described herein and Installer's policy of warranty. After acceptance of bid, all conditions and requirements of warranty described herein shall apply.

1. The Installer shall guarantee all provided equipment, materials, and labor for a period of 2 years (per Owner requirement) from the date of final acceptance.
2. At time of initial bid, provide line-item pricing for Year 3, Year 4 and Year 5 extended service contract. (Broken out for each additional year, not lump sum).
3. Equipment that the Installer does *not* provide as part of this contract is exempt from this warranty coverage. However, the installation labor and materials associated with any equipment installed by the Installer, including OFCI items, shall be covered under this warranty.
4. During the warranty period, within 24 hours of notification, the Installer shall answer all service calls and requests for information.
5. During the warranty period, within 72 hours of original notification, the Installer shall provide emergency service to restore operation of the system, replacing defective materials, repairing faulty workmanship, making temporary repairs, and providing loaner equipment as necessary, all at no charge.
6. The Installer shall notify the Owner after any service call whether such call is or is not covered under the warranty. The Owner may be billed for non-warranty calls. The Installer shall notify the Owner of any service call or work to be performed for which charges may be incurred *before* such work commences.

7. Improper functioning, for warranty purposes, means failure of the system to meet the intentions of the specification because of internal defects. It does not include Owner-caused malfunctions such as re-adjustment of the controls, re-tuning of the system, or injury to the system beyond normal wear. Nor does the warranty cover paint, exterior finishes, fuses, lamps (including projection lamps) or associated labor, unless the damage or failure results from defective materials or workmanship covered by the warranty.
8. The Installer shall take such actions at the time of installation to ensure that all equipment is installed in accordance with the manufacturer recommended environmental and electrical operating conditions and requirements. After installation, the Installer shall be responsible for the repair or replacement of said equipment that the Installer provided which fails due to environmental or electrical conditions, even if not covered by the manufacturer's warranty. The Installer shall not be held responsible for damages due to changes in environmental conditions which occur after system acceptance.
9. If the Installer has modified certain components, the manufacturer's warranty for such components may become void. In such a case, the Installer is responsible for providing warranty coverage equal to that originally provided by the manufacturer.
10. Certain subsystems and system components may require installation by authorized representatives in order for the complete manufacturer warranty to apply. If this pertains to any subsystem or component for this project, it is the Installer's responsibility to make arrangements for the complete manufacturer warranty to apply. These arrangements are to be made at no additional cost to the Owner.

1.15 SERVICE CONTRACT

A. As part of this Specification, the Contractor shall initiate a one-year service contract to commence on the date of final acceptance and continue to the first anniversary of the date of final acceptance as defined in 'System Acceptance'. The scope of the service contract would normally extend beyond warranty service calls, to include ongoing support of the AV systems such as maintenance, periodic replacement of consumables, Owner training or assistance, and/or additional design-build agreements.

B. As part of the Bid Response, the Contractor shall provide the Owner with a proposal for continuation of the service contract to include Year Two, Year Three and Year Four of operation. All terms and conditions of the Year One Warranty shall apply.

1.16 PRIOR APPROVAL

A. For substitutions of products specified herein, Contractor shall submit requests for prior approval at least 10 days prior to submitting bids, and in accordance with the provisions of Bidding Instructions and/or Division 1.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide products quantities as required. If a quantity is given, provide at least the given amount.

B. Products shall be new, free from defects and listed by UL when an applicable UL Standard exists. Provide Products of a given type from one manufacturer.

C. Regardless of the length or completeness of the descriptive paragraph under article titled “Manufacturers and Products”, provide Products complying with the specified manufacturer's published specifications.

D. Take care during installation to prevent scratches, dents, chips, etc.

2.02 MANUFACTURERS AND PRODUCTS

A. For list of “basis of design” manufacturers and part numbers, refer to the AV Functional Diagrams on the drawings.

B. If a specified product has been discontinued by a manufacturer, provide the replacement model (as certified by the manufacturer) at no additional cost.

C. Where required provide manufacturer’s rack mount adapter or one manufactured by Middle Atlantic.

D. Provide complete and fully functional systems, including items that are not explicitly described herein, but are necessary for a complete functioning system which shall adhere to the performance parameters as described on the drawings and/or required by these specifications. Items shall include, but are not limited to, all required mounting hardware and faceplates.

2.03 SOFTWARE

A. All commercial software used, shall be registered to Owner, in Owner’s name. Owner to be supplied with all software documentation including copies of software registration.

B. For any software required to be installed on owner-provided hardware, shall be loaded and tested. Any required updates shall be installed and configured.

C. Coordinate all management, control and monitoring functions with the Owner. Minimum requirements shall include:

1. System control of individual systems
2. Positive feedback on from controlled devices. (e.g., projector lamp timer)
3. Lighting control – where specified on electrical drawings and lighting control specifications.

D. Provide all manufacturer's commercially available software.

2.04 CABLING

A. Provide all cabling – both within conduits and raceways, as well as loose or "spare" or "portable" – for a complete functioning system. Not all cabling is specified on the drawings and/or specifications. Contractor is responsible for supplementing cabling as necessary.

B. Refer to Section 27 1622, Cabling for Audio-Visual Systems as well as APPENDIX A attached to the end of this Section.

2.05 PRODUCT SUBSTITUTIONS

A. Refer to "Prior Approval" in Part 1 of this document.

B. The materials and products specified herein reflect the minimum acceptable standards of fabrication and manufacture. All materials and products supplied by the Contractor and specified herein are to be new, unused, of first quality and in original packaging or shipping containers or as shown on drawings.

C. The products listed herein are pre-approved for this project. Substitutions shall be permitted for the manufacturers and products contained herein, provided they equal or exceed the specifications thereof and are approved via formal request.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

B. Examine roughing-in for LAN and control cable conduit systems to AV equipment, PCs, speakers, microphones and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Comply with EIA/TIA-606, "Administration Standard for the Telecommunications Infrastructure of Commercial Buildings."

B. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

3.03 GENERAL INSTALLATION PRACTICES

A. All equipment with the exception of portable equipment shall be firmly fastened or attached in place. A safety factor of at least four shall be utilized for all brackets, fasteners and attachments.

B. In the installation of equipment and cable, consideration shall be given not only to operational efficiency, but also to overall aesthetic factors.

C. The Contractor shall insure that all equipment is installed such that proper cooling and ventilation is insured.

D. All equipment shall be installed in a manner, which prevents hum, RF/EMI/EMF interference, and mechanical vibration based noises (e.g. fan mounts, etc.)

E. All equipment shall be protected from construction dust and debris until final acceptance of the system.

F. All equipment shall be protected from theft until final acceptance of the system.

G. The Contractor shall be under obligation to protect completed work and uncompleted work against damage or loss until the Owner has given final acceptance. Should the need arise to repair work or replace items. The Contractor shall do so at no cost to the Owner.

3.04 FURNITURE

A. The Contractor shall ensure that equipment or mounting hardware is compatible with and suitable for installation in furniture specified by the Architect, Consultant, or Furniture Supplier. It shall further be the Contractor's responsibility to ensure that such coordination with the Architect, Consultant, or Furniture Supplier occurs. The Contractor shall exchange with and follow such Shop Drawings as to ensure that dimensions and structural supports are adequate for the installation of specified equipment. It is the Contractor's responsibility that the request and delivery of such critical coordination information is satisfactorily executed. Inasmuch as the Contractor has control over the delivery of such information, he shall deliver it as requested by the Architect, Consultant, or Furniture Supplier.

3.05 EQUIPMENT RACKS AND CABLE MANAGEMENT

A. Racks shall be installed in such a way so as to permit access to all equipment for service.

B. All equipment in racks shall be fitted with vent panels and/or fans as required to provide ventilation and cooling according to equipment manufacturer's recommendations.

C. Adjacent racks shall be bolted together with appropriate ganging hardware.

D. As a general practice, all power cables, control cables, and high-level cables shall be dressed to the left rear of an equipment rack. Audio and video cables shall be dressed to the right rear of the rack. Audio, video and control cables shall be bundled separately and spaced not less than three (3) inches apart.

E. Internal equipment rack cabling shall be supported by lacing strips, support brackets, or other cable management systems as required to ensure that all cabling is supported in both the vertical and horizontal planes within the rack.

F. With the exception of ganged equipment rack assemblies, cabling routed between equipment racks or pieces of equipment exterior to equipment racks, or extending to the greater facility cabling infrastructure, shall be completely protected, end-to-end, by a raceway, wire-way, or duct appropriately sized for the cable run.

G. Cabling between rolling pieces of equipment not housed in rack cabinets or a rolling equipment rack and any device to which it is connected, shall be protected by a split-loom corrugated tubing wrap or other such flexible cable management system appropriately sized for the cable run.

H. Any controls not to be adjusted by the user and accessible from the front of the equipment rack must be furnished with security panels.

I. UL Listing: Rack system shall be UL Listed in the US and Canada.

3.06 CABLING

A. Refer to Section 27 1622, Cabling for Audio-Visual Systems.

3.07 GROUNDING

A. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

B. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

C. Bond shields and drain conductors to ground at only one point in each circuit.

3.08 IDENTIFICATION

A. All equipment components shall be identified with a unique, permanently affixed laser-engraved label. Provide a schedule or database of labels and identifiers to

Owner at completion of project installation.

B. Cable Labeling: Comply with Section 27 1622, Cabling for Audio-Visual Systems.

C. At completion, all labels and schedules shall reflect as-built conditions.

3.09 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. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports as required.

C. System Set-up and Tuning

1. Optimization: The Contractor shall install, configure, adjust, program, and calibrate all components in order to optimize the performance of all individual subsystems and the system as a whole.

D. Preliminary Tests:

1. General: Once the system is installed, the Contractor shall complete the following preliminary tests and prepare a written test report for the Consultant. The test report will list the results of each of the tests described in this section and certify that the installation is complete.
2. Control: Upon completion of installation, the Contractor shall test each function of each control station, push-button panel, touch screen panel, computer control interface, and all components connected to or interfaced to the Control System to verify proper operation and that each switch and indicator operates as intended.
3. Audio: The Contractor shall perform the following tests:

    a. Prior to the termination of audio amplifiers to speakers, the Contractor shall measure the resistance of the speaker line with reference to ground to determine that no short circuits or paths to ground exist in the line. The Contractor shall connect the speaker to the cable and measure the impedance of each speaker line using a 1,000Hz signal applied to the line. The Contractor shall submit a list, to the Consultant, by cable number, of the impedance of each speaker line. This test shall be performed with the amplifier disconnected from the speaker line and the speaker connected to the speaker line.
    b. Verify all loudspeakers are functioning.
    c. Verify that the system meets all Performance Requirements as outlined in this section.
    d. Verify that all equipment, panels, and cables are labeled correctly.

e. Verify each item of equipment is functioning as intended.
f. Verify the installation is the same as specified.

E. Video: To establish that the facility cabling and terminations meet the specifications defined in 'Performance Standards', a video test signal shall be applied to each input cable and passed through the system switching and distribution networks with the results measured at each system output. In addition, the Contractor shall:

1. Verify each item of equipment is functioning as intended.
2. Verify the installation is the same as specified.

F. Final Tests

1. Upon approval of the Contractor's test report, and at a time that is mutually acceptable to the Contractor, Owner and Consultant, the Contractor shall assist the Consultant and Owner in final system tests and adjustments. The Contractor shall allow two (1) day to perform the tests. The Contractor's representatives assisting in the performance of these tests shall be thoroughly familiar with the details of the system and shall include the field supervisor responsible for installing the system.
2. To demonstrate the good working order of all playback devices in the system the Contractor shall make available high quality source materials for all audio and video media types represented in the system. To demonstrate the good working order of all computer-video displays the Contractor shall make available the computer-video signal generator described in 'Performance Standards – Preliminary Tests and Submittals – Computer Video Display Devices'. In addition, the Contractor shall make available a laptop computer with the ability to output 1440 x 900 (WXGA+/WSXGA), 1680 x 1050 (WSXGA+), 1920 x 1080 (Full HD), 1920 x 1200 (WUXGA), 2048 x 1152 (QWXGA), 2736 x 1824 (Surface Pro 4), 2880 x 1800 (QWXGA+ / MacBook Pro), and 3840 x 2160 (4K UHD) graphics with at least 16bit color depth. The computer shall be capable of displaying spreadsheets, graphs, charts, pictures and text of varying sizes and fonts to effectively demonstrate the systems computer display imaging capabilities.
3. The Contractor shall demonstrate operation of all subsystems, including audio and video recording, displays, cameras, camera controls, streaming, control system and so on, meets or exceeds the criteria as outlined in this section.

G. Remove and replace malfunctioning devices and circuits and retest as specified above.

3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service as needed. Complete installation and startup checks according to approved procedures and with manufacturer's written instructions.

3.11 PROTECTION

A. Maintain strict security during the installation of equipment and software. Rooms housing the AV components that have been powered up shall be locked and secured, with an activated access-control system or keyed system during periods when a qualified operator in the employ of Contractor is not present.

3.12 DEMONSTRATION AND TRAINING

A. Train Owner's staff personnel to adjust, operate, and maintain AV system. Refer to Division 01 Section "Demonstration and Training."

B. The Contractor shall provide a total of four (4) hours of on-site training for the Owner's staff at a time that is mutually agreeable for the Owner and Contractor. The Contractor should anticipate two sessions of two hours each. The Owner may choose to have the sessions spread out over a maximum of three different days. Final acceptance and/or final payment for the system shall not be delayed due to scheduling delays beyond the control of the Contractor.

C. In addition, the Contractor is responsible for scheduling and coordinating the specified manufacturer training with the Owner.

3.13 SYSTEM ACCEPTANCE

A. Upon successful completion of Final Tests, Documentation and Training, the Contractor shall notify the Owner, in writing, that the system is complete. The Owner shall have fifteen (15) days to generate a "punch list" of omissions, adjustments, corrections and the like and respond in writing to the Contractor. In the absence of such a "Punch List," the system shall be considered to be complete. The warranty shall commence on the fifteenth day after the Contractor's notification of completion of work, and the Owner shall process final payment. In the event that further work is required to complete this project, the Contractor shall be prepared to continue work, without additional compensation, until the system is accepted.

END OF SECTION 274100

SECTION 274122
CABLING FOR AUDIO-VISUAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of cabling and connectors as described on the Drawings and/or required by these specifications.

B. Related Sections: The following Sections contain requirements that relate to this Section.

1. Division 26 (Electrical): Power supply, conduit and wiring.
2. Division 27, Section 27 4100, Audio-Visual Systems.
3. Division 27, Section 27 4181, Audio-Visual Control System.
4. Division 27, Section 27 5213, Projection Screens.

1.03 REFERENCES

A. Underwriters Laboratories Inc. (UL)

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. Include physical characteristics, UL classification types, conductor sizes, nominal impedances, and nominal capacitances. Reference each product to a location or "type" on Drawings. Test and evaluation data.

B. Shop Drawings: The shop drawings listed below are required of the Contractor. Submit all Shop Drawings complete as a single submission. Isolated items will not be accepted, except with prior approval.

1. Cabling Schedule: A list containing the cable type, cable marker identifier, and origination and destination location and connector types for each cable.
2. Examples of the Contractor's final cable marking technique for each cable type.

1.01 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by InfoComm on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings**,** Cabling Administration Drawings, and field testing program development by a CTS, CTS-D, or CTS-I.
2. Installation Supervision: Installation shall be under the direct supervision of a CTS or CTS-I certified Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by the manufacturer of the connected equipment to supervise on-site testing.

1.02 QUALIFICATIONS

A. Audio-Visual Systems Cabling: The Contractor shall have 5 (five) years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and 3 (three) years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a 3 (three) year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or InfoComm certified installer for every two non-certified installers assigned to the project.

B. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or InfoComm.

1.

1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of 5 years' experience in like work.
2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the Owner.

1.05 PRIOR APPROVAL

A. For substitutions of products and/or manufacturers specified herein, Contractor shall submit requests for prior approval. Comply with provisions of Bidding Instructions and/or Division 1.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protection: Protect products from damage that may be caused by exposure to

water, chemicals, direct sunlight or infestation.

B. Waste Management and Disposal: Separate waste materials for recycling in accordance with Division 01, Section "Construction Waste Management and Disposal".

1. Remove packaging materials from site and dispose of at appropriate recycling facilities.
2. Collect and separate for disposal paper, plastic, corrugated cardboard and/or polystyrene packaging materials in appropriate onsite bins for recycling.
3. Dispose of all non-recyclable packaging materials and debris in a safe and environmentally responsible manner according to the instructions set forth by the General Contractor, local ordinances or codes and the Environmental Protection Agency.

PART 2 - PRODUCTS

2.01 GENERAL

A. Available Manufacturers: Subject to compliance with requirements, provide makes and models as listed below.

B. The materials and products specified herein reflect the minimum acceptable standards of fabrication and manufacture. All materials and products supplied by the Contractor and specified herein are to be new, unused, of first quality and in original packaging or shipping containers or as shown on drawings and described in Part 3 below (for cabling).

C. The products listed herein are pre-approved for this project. Substitutions shall be permitted for the manufacturers and products contained herein, provided they equal or exceed the specifications thereof and are pre-approved via formal request.

2.02 BULK CABLING

NOTE: Not all cable types listed are used in this project.

Cabling for Audio-Visual Systems
Schedule of Approved Bulk Cabling

Type/ ID	Signal Type / Application	Cable Type	Manuf.	Model	OSP/ Plenum	Nominal O.D. (in)
ANALOG AUDIO						
AA01	Mic / Line Audio (Mono Signal)	22 AWG STP	Belden	8450	-	0.118
			Belden	82761	Plenum	0.116
			Liberty	22-1P-EZ	-	0.142
			Liberty	22-1P-CMP-EZ	Plenum	0.130

AA02	Mic / Line Audio (Stereo Signal)	22 AWG STP	Belden	8723	-	0.160
			Belden	82723	Plenum	0.153
			Liberty	22-2P-INDSH-GRY	-	
			Liberty	22-2P-PINDSH-WHT	Plenum	
AA03	Mic / Line Audio (Snake, 3 Pair)	22 AWG STP	Belden	8777	-	0.273
			Belden	82777	Plenum	0.234
			Liberty	22-3P-INDSH-GRY	-	
			Liberty	22-3P-PINDSH-WHT	Plenum	
AA04	Mic / Line Audio (Snake, 4 Pair)	22 AWG STP	Belden	8778	-	0.362
			Belden	82778	Plenum	0.309
			Liberty	22-4P-INDSH-GRY	-	
			Liberty	22-4P-PINDSH-WHT	Plenum	

LOUDSPEAKER						
L01	Loudspeaker (Constant Voltage)	18 AWG UTP	Belden	8461	-	0.234
			Belden	6300UE	Plenum	0.157
			Liberty	18-2C-GRY	-	0.160
			Liberty	18-2C-P	Plenum	0.195
L02	Loudspeaker (Constant Voltage)	16 AWG UTP	Belden	8471	-	0.274
			Belden	6200UE	Plenum	0.180
			Liberty	16-2C-GRY	-	0.183
			Liberty	16-2C-TTP	Plenum	0.217
L03	Loudspeaker (Low-Impedance)	14 AWG UTP	Belden	8473	-	0.340
			Belden	5100UP	Plenum	0.260
			Liberty	14-2C-GRY	-	0.230
			Liberty	14-2C-TTP	Plenum	0.216
L04	Loudspeaker(Low-Impedance)	12 AWG UTP	Belden	8477	-	0.386
			Belden	5000UP	Plenum	0.302
			Liberty	12-2C-GRY	-	0.274
			Liberty	12-2C-TTP	Plenum	0.257
L05	Loudspeaker (Low-Impedance)	10 AWG UTP	Belden	5T00UP	-	0.356
			Belden	6T00UP	Plenum	0.308
			Liberty	10-2C-KO-WHT	-	
			Liberty	10-2C-TTP-WHT	Plenum	
RF DISTRIBUTION						
RF01	50-ohm Antenna (Low Loss)	20 AWG Coax (RG-58 Type)	Belden	8240	-	0.193
			Belden	88240	Plenum	0.159
			Liberty	RG58-CMR	-	0.195
			Liberty	RG58-CMP	Plenum	0.178
RF03	75-ohm TV Distribution (RF)	18 AWG Coax (RG-6 Type)	Belden	1530A	-	0.270
			Belden	1530AP	Plenum	0.235
			Liberty	RG6-CM-BLK	-	
			Liberty	RG6-P-CATV-WHT	Plenum	

UTP						
U01	Ethernet/ A/V over UTP (Cat5e)	24 AWG UTP (4pr)	Belden	1700A	-	0.200
			Belden	1701A	Plenum	0.195
			Liberty	24-4P-L5-EN	-	0.197
			Liberty	24-4P-P-L5-EN	Plenum	0.180
U02	Ethernet/ A/V over UTP (Cat6)	23 AWG UTP (4pr)	Belden	7851A	-	0.315
			Belden	7852A	Plenum	0.290
			Liberty	24-4P-L6-EN	-	0.220

			Liberty	24-4P-P-L6-EN	Plenum	0.215
			Berk-Tek	10139885	OSP	0.250
U12	A/V over UTP (Cat5e Low-Skew)	24 AWG UTP (4pr, Low-Skew)	Belden	7988R	-	0.204
			Belden	7988P	Plenum	0.193
U13	A/V over UTP (Cat6 Low-Skew)	23 AWG UTP (4pr, Low-Skew)	Belden	7989R	-	0.365
			Belden	7989P	Plenum	0.365
			Liberty	TRUPHASE	-	0.205
			Liberty	TRUPHASE-P	Plenum	0.170
STP						
S01	Ethernet/ A/V over STP (Cat5e)	24 AWG ScTP (4pr)	Belden	1533R	-	0.260
			Belden	1533P	Plenum	0.235
			Liberty	24-4P-L5SH-EN	-	0.237
			Liberty	24-4P-P-L5SH	Plenum	0.225
S02	Ethernet/ A/V over STP (Cat6)	23 AWG ScTP (4pr)	Belden	1351A	-	0.290
			Belden	1352A	Plenum	0.285
			Liberty	24-4P-L6SH	-	0.270
			Liberty	24-4P-P-L6SH	Plenum	0.268
CONTROL						
C01	IR & Serial Control (RS-232/-422)	24 AWG STP (4pr)	Belden	8104	-	0.302
			Belden	88104	Plenum	0.259
			Liberty	24-4P-SH-LIBII	-	0.210
			Liberty	24-4P-PLCSH	Plenum	0.210
C02	Serial Control (RS-485) or DMX-512 (4-cond)	24 AWG STP (2pr)	Belden	9842	-	0.340
			Belden	82842	Plenum	0.273
			Liberty	24-2P-485	-	0.326
			Liberty	24-2P-P485-WHT	Plenum	0.277
C11	Dry Contact & Signal Input/Output	22 AWG STP (1pr)	Belden	8761	-	0.175
			Belden	82761	Plenum	0.116
[End]						

PART 3 - EXECUTION

3.01 STANDARDS

A. All cabling and termination shall be executed in adherence to standard industry practices such as those outlined in the following:

1. NECA 1, *Good Workmanship in Electrical Contracting*
2. Philip Giddings, *Audio Systems Design and Installation*. Boston: Focal Press, 1990.
3. Kenneth T. Deschler, *Cable System Design and Installation*. McGraw-Hill, Inc. 1987.
4. InfoComm International, *AV Installation Handbook – Second Edition: The*

Best Practices for Quality Audiovisual Systems. InfoComm International, 2007. Fairfax, VA

3.02 EXAMINATION

A. Site Verification of Conditions:

1. Verify that conditions of substrates and pathways previously installed under other sections or contracts are acceptable with cable installation.
2. Inform Owner of unacceptable conditions immediately upon discovery.
3. Proceed with installation only after unacceptable conditions have been corrected.

3.03 CABLE LENGTHS

A. Cable Length Verification: Cable lengths where given in the Specification, for bulk or manufactured cable assemblies, have been provided to assist the Contractor in the bidding process. Cable run lengths, where specified, are end-point-to-end-point estimates and include consideration for tails. Estimates may be based upon cable tray systems; raceways, conduit runs, and furniture layouts indicated on construction drawings and may vary from the actual installed cable pathways.

B. It is responsibility of the Contractor to field verify required cable lengths for bulk cable or manufactured cable assemblies prior to ordering.

3.04 INSTALLATION

A. Non-contiguous cable support mechanisms such as hangers, rings, and hooks shall not be spaced farther than four (4) feet apart. All manufactured raceways used for cables shall be installed according to the raceway manufacturer's specifications.

B. Cable runs shall be supported with devices designed for this purpose and are to be installed independent of any other structural component.

C. Cables routed vertically up walls, or between floors as vertical riser, shall be supported with clamps or other mechanisms. These supports shall occur at least three times per floor.

D. Cable pulling tension may not exceed manufacturer recommendations. Where cable-pulling lubricant is used, the lubricant must be compatible (non-damaging) with the conduit and cable sleeve materials and must not harden over time to prevent future pulls.

E. Cable stapling of any recognized media type shall not be permitted.

F. Cables shall be dressed in conveniently sized bundles and either laced or banded. Lacing or banding shall not be so tight as to deform cable bundles.

G. Cabling installed with a bend radius less than that recommended by the cabling

manufacturer is not acceptable.

H. Cables and bundles terminating at equipment or connector panels shall be supported so as not to put strain on connections or connectors.

I. All cables, with the exception of video or pulse cables, which must be cut to an electrical length, shall be cut to the length dictated by the run. No splices shall be permitted in any pull boxes without prior approval of the Consultant.

J. Cabling for equipment mounted in drawers or on slides shall be provided with a service loop of appropriate length. A cable management support for the service loop shall be provided to prevent the service loop travel from interfering with the operation of the drawer or slide, or snagging on adjacent cabling.

K. Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

L. Microphone level, line level, loudspeaker level, and video lines shall all be run in separate conduits, trough, raceway divider, and cable bundles. Low voltage DC and control may be run along with any but microphone- or line- level audio cable runs.

M. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

N. Install LAN cables using techniques, practices, and methods that are consistent with Category 6 rating of components and that ensure Category 6 performance of completed and linked signal paths, end to end.

O. Install cables without damaging conductors, shield, or jacket.

P. Repair damage to adjacent materials caused by cable work.

3.05 TERMINATION

A. Contractor to follow approved Manufacturer procedures for termination instructions for the specific products being installed.

B. All termination components must meet or exceed all specifications for given media type and application as described in this document and system drawings.

C. Crimp on connectors shall be installed only on the appropriate size cable using the manufacturer recommended crimp tool and die set.

D. Connections to electronic devices providing screw terminals shall be terminated using the appropriate gauge insulated spade or ring crimp terminal connector and crimp tool.

E. All mechanical solder-on connectors shall be attached to cable ends using rosin core solder.

F. Audio signal cable shields shall be protected with the appropriate gauge Teflon or heat-shrinkable tubing. The jacket end of each audio cable shall be fitted with the appropriate gauge heat shrinkable tubing to provide additional protection to the base of the shield or shield foil. This also applies to the inside of mechanical connectors and cables that terminate at partitioned barrier strips.

3.06 GROUNDING

A. Comply with Division 26 requirements for grounding and bonding for electrical systems.

B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Bond shields and drain conductors to ground at only one point in each circuit.

3.07 IDENTIFICATION

A. In addition to requirements in this Article, comply with applicable requirements in Division 26 requirements for identification for electrical systems and with TIA/EIA-606.

B. Labeling:

1. Label products in a logical, legible and permanent manner corresponding to the Drawings. Wording, format, style, color and arrangement of text will be subject to the Architect's approval.
2. Label all wall plates for input, output and control receptacles as well as connector mounting plates in floor boxes using 1/8" engraved lettering filled with black paint if plate is light colored and filled with white paint if plate is dark colored.
3. Provide engraved labels similar to Lamicoid, Traffolyte or equal and approved, squarely and permanently attached to label patch panels, barrier strips, terminals, transformers, switches, relays and similar devices as well as front and rear of all signal processing equipment (e.g. PA, LIM, EQ). Label all controls on distribution amplifiers, mixers, etc. as to the function of each.
4. Label all permanent wiring on both ends with approved permanent clip-on type or sleeve type markers. Wrap-around adhesive labels will not be accepted unless completely covered with clear heat shrink tubing.
5. Label all portable equipment with permanent labels showing ownership by Owner. Label all portable cables similarly with printed heat-shrinkable tags located 12 inches from the male connector end. Use 1/8" block letters and verify acceptability of wording with the A/V Design Consultant prior to engraving or printing labels.

6. Sample labels:

(DVD Wire End)	(Router Wire End)
CABLE # A107 DVD-1 AUDIO IN L ROUTER AUDIO OUT 12L	CABLE # A107 ROUTER AUDIO OUT 12L DVD-1 AUDIO IN L

C. At completion, all cabling labels and schedules shall reflect as-built conditions.

3.08 CLEANING

A. Upon completion, remove surplus materials, trash, tools and equipment.

END OF SECTION 274122

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