NATIONAL RENEWABLE ENERGY LABORATORY

CONSTRUCTION SPECIFICATIONS

FOR

FY 19 Lab Upgrades
VTIF

Prepared By:

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ISSUED: 03/27/2020
ISSUED FOR: CONSTRUCTION

SPECIFICATIONS
TABLE OF CONTENTS

Section No.	Title	Version Date

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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)

END OF SECTION

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SECTION 012300
ALTERNATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide alternate bid proposals as described in this Section.

B. Related Sections

1. Alternates mentioned in this Section are described further in pertinent other Sections of these Specifications and on the Drawings. All contract documents are applicable to all alternates identified.

1.2 REFERENCES

1.3 DEFINITIONS

A. Provide alternate bids to be added to the amount of the Base Bid if the corresponding change is accepted by the Owner.

B. Include within the alternate bid prices for all costs, including materials, installations, and fees.

C. Show the proposed alternate amounts opposite their proper description of the Bid Form.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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 hours 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. 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. Subcontractor work

   f. Equipment installations

   g. Testing of Equipment

   h. Operational check out

   i. 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) Applications for payment
      4) Environmental control plans
      5) 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.

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

NREL PROJECT TITLE **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.
220500	X							X					
220519		X							X				
220529		X							X				
220553	X			X									
220700	X	X		X									
221116		X											
226113		X											
230500		X						X					
230593	X					X		X					
230900		X	X						X				
232300		X	X										
238126		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.
260500		X	X										
260519		X											
260526						X							
260529		X											
260533		X	X										
260553	X												
260810			X			X							
262726		X				X			X				

END OF SECTION

SECTION 013500
HAZARDOUS MATERIALS REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. General administrative requirements and procedures for Hazardous Communications Program.

B. Related Sections

1. Section 011100 - Summary of Work
2. Storm Water Pollution Prevention Plan

1.2 DEFINITIONS

A. Definitions: Definitions of terms and other _____ considerations as set forth in the:

PART 2 - PRODUCTS

PART 3 - EXECUTION

END OF SECTION

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SECTION 013543.01
ENVIRONMENTAL PROCEDURES FOR STORMWATER PERMITTING

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included. Obtain stormwater permit coverage from the Environmental Protection Agency, Colorado Department of Public Health and Environment and/or other jurisdiction, as required; comply with all permit conditions and requirements identified in this section.

B. Applicability. The specific requirements identified in this section apply only to construction projects located at NREL's South Table Mountain and National Wind Technology Center for which permit coverage is obtained under the EPA's National Pollutant Discharge Elimination System General Permit for Discharges from Construction Activities (referred to in this section as the EPA CGP). Construction at other project sites must follow the specific requirements of the agency with jurisdiction at that location.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections apply to this Section.

B. Section 015050 Construction Waste Management

C. Section 311000 Site Clearing

D. Section 312000 Earth Moving

E. Section 312333 Trenching and Backfilling

F. Section 312500 Temporary Erosion and Sedimentation Control

G. Section 328400 Planting Irrigation

H. Section 329100 Planting Preparation

I. Section 329113 Mulching

J. Section 329200 Native Sod and Grasses

K. Section 329300 Plants

1.3 REFERENCES

A. Environmental Protection Agency National Pollutant Discharge Elimination System General Permit for Discharges from Construction Activities, EPA Construction General Permit

B. Colorado Department of Public Health and Environment Stormwater Discharges Associated w/ Construction Activities COR030000. CDPS General Permit

C. City of Aurora. City of Aurora Stormwater Rules and Regulations

D. Urban Drainage and Flood Control District Criteria Manual Volume 3. Urban Storm Drainage Criteria Manual Volume 3

1.4 BACKGROUND

A. The Federal Clean Water Act (CWA), CWA amendments, and implementing regulations apply to stormwater discharges from construction activities that disturb greater than one acre or that disturb less than one acre but that are part of a larger common plan of development. The EPA is the regulating authority for stormwater discharges from construction activities at both the NREL South

Table Mountain (STM) and National Wind Technology (NWTC) sites. Consequently, construction projects at these facilities that disturb greater than one acre or that disturb less than one acre but are part of a larger common plan of development must apply for coverage under the EPA Construction General Permit (EPA CGP). The key elements of the EPA CGP are filing a Notice of Intent (NOI) to be covered under the EPA CGP and preparation of a site-specific Stormwater Pollution Prevention Plan (SWPPP).

B. NREL, DOE and the construction Contractor apply for stormwater permit coverage at all NREL STM and NWTC construction sites when earth disturbance exceeds one acre or when earth disturbance is less than one acre but part of a common plan of development. Only the Contractor applies for stormwater permit coverage at NREL's leased sites. Stormwater permitting at NREL's leased sites is not addressed in this Section.

C. Stormwater permit coverage from the EPA is not required for construction projects that disturb less than one acre at the NWTC and STM campuses. However, documentation as described in this Section is required by the NREL EHS Office.

1.5 DEFINITIONS

A. Best Management Practice (BMP). BMPs are structural erosion and sediment controls, materials management practices, maintenance procedures, and other practices used to prevent or reduce the discharge of pollutants to waters of the U.S.

B. Corrective Actions. Corrective actions are actions taken to:

1. Repair, modify, or replace any stormwater control used at the site
2. Clean up and properly dispose of spills, releases or other deposits, or
3. Remedy a permit violation.

C. Disturbed Area. An area where the existing vegetation and soil surfaces are removed or otherwise affected by construction activities. These can include areas within construction site fencing as well as haul roads, laydown areas, and stockpile areas.

D. Environmental Protection Agency Construction General Permit (EPA CGP). The National Pollutant Discharge Elimination System General Permit for Discharges from Construction Activities (hereafter referred to as the Environmental Protection Agency Construction General Permit or EPA CGP), developed by the Environmental Protection Agency (EPA) that establishes requirements to protect stormwater quality at construction sites that disturb greater than one acre or that disturb less than one acre but are part of a larger common plan of development. Permit holders must comply with requirements identified in the 2012 EPA CGP, among which include filing a Notice of Intent to be covered under the permit and development of a Stormwater Pollution Prevention Plan (SWPPP).

E. Notice of Intent (NOI). A form that must be completed and provided to the EPA when requesting coverage under the Environmental Protection Agency Construction General Permit. This information is filed electronically through the Environmental Protection Agency's electronic NOI (eNOI) website.

F. Notice of Termination (NOT). A form that is completed and filed through the EPA eNOI website at the conclusion of construction when EPA CGP stabilization criteria have been met. Alternatively, a NOT may be filed when another operator has assumed control of the construction site or when the construction site is being covered under a new or existing NOI coverage.

G. Runoff. Water originating from precipitation, snowmelt, excess irrigation water, and other sources that ultimately flows into drainage facilities, rivers, streams, ditches, springs/seeps, ponds, lakes, or wetlands.

H. Site-Specific Erosion and Sediment Control Plan. A drawing(s) or map(s) included in the Stormwater Pollution Prevention Plan that graphically identifies the type and location of best management practices to be used on a construction site to prevent sediment and other potential pollutants from entrainment in stormwater runoff. The site-specific erosion and sediment control plan also shows laydown, staging, and stockpile areas as well as other items required by Section 7.26 of the 2012 Environmental Protection Agency Construction General Permit . These plans are required for construction sites at NREL, including those that involve less than one acre of earth disturbance.

I. Stormwater Pollutant. May include one or more of the following: sediment, oil, grease, nitrogen, phosphorus, bacteria, fuel, debris, and a variety of hazardous chemicals that are used at construction sites.

J. Stormwater Pollution Prevention Plan (SWPPP). A detailed plan that outlines how sediment and erosion controls and other best management practices will be implemented at a construction site to manage stormwater runoff and protect stormwater quality. A SWPPP is required for construction sites that apply for coverage under the Environmental Protection Agency Construction General Permit. An abbreviated version may be required by NREL for sites that involve earth disturbance of less than one acre and have the potential to discharge pollutants to stormwater.

K. Waters of the U.S. A regulatory phrase used to describe those waters subject to federal and state regulation within the United States, The nearest waters of the U.S. to the NREL facilities include Lena Gulch at the STM site and Coal Creek and Rock Creek at the NWTC site.

1.6 PERFORMANCE STANDARDS

A. Read and abide by all requirements of the EPA CGP for stormwater discharges associated with construction activities whose earth disturbance exceeds one acre or that disturb less than one acre but are part of a larger common plan of development at the NREL NWTC and STM campuses.

B. Prevent spills and leaks of chemicals, oils and fuels from coming into contact with stormwater and snowmelt and from being discharged into the storm drain system.

C. Comply with all applicable local, state and federal rules, regulation, ordinances, codes and standards. In case of conflict between the above rules, regulations, ordinances, codes and standards and these specifications, the more stringent requirements shall govern.

D. Attend preconstruction conference as directed by the NREL Project Manager prior to the start of construction. Contractor to comply with requirements which may also be included in Division 1 Section “Project Management and Coordination”.

1.7 SUBMITTALS

A. All submittals are to be made to the NREL Project Manager. If provided, refer to Division 1 Section “Submittal Procedures”.

B. Stormwater Pollution Prevention Plan (SWPPP): Contractor must submit a draft SWPPP for NREL EHS Office review. The SWPPP, which includes a Site-Specific Erosion and Sediment Control Plan, must be accepted by the NREL EHS Office prior to Contractor NOI submittal to the EPA.

C. Notice of Intent (NOI): Contractor must file a NOI via the EPA’s eNOI website for coverage under the EPA CGP at STM and NWTC construction projects where construction activities will disturb

greater than one acre or that will disturb less than one acre but are part of a larger common plan of development. A draft NOI must first be reviewed and approved by the NREL EHS Office. NREL and DOE will also file NOIs for construction projects at the NWTC and STM campuses that disturbs greater than one acre or that will disturb less than one acre but are part of a larger common plan of development.

D. Pre-Disturbance Vegetative Cover Assessment: Prior to commencement of earth-disturbing activities, Contractor must submit to NREL a pre-disturbance vegetation assessment. The NREL must review and approve this document prior to the commencement of earth-disturbing activities. The approved plan must be filed within the project SWPPP. The assessment must identify the following:

1. A description of the general type and condition of existing vegetative cover
2. Photographs of pre-disturbance cover
3. Percent vegetative cover for the site prior to earth-disturbing activities (If the site is large and diverse, preconstruction percent vegetative cover must be calculated for distinct zones within the project boundaries).
4. A calculation of the target post-construction percent vegetative cover (70 percent of pre-disturbance vegetative cover) for the site (or distinct zones). This percent cover must be achieved for EPA CGP termination and for NREL acceptance at the conclusion of a Contractor warranty period.

E. Pesticide/Herbicide Application Plan (If pesticides/herbicides will be used): When pesticides and herbicides must be applied for road base preparation, revegetation efforts or other construction related needs, the Contractor shall prepare a written request and obtain approval from NREL's EHS Office for the use of those chemicals two days prior to their use.

F. Discharge Plan for Accumulation of Water in Excavations (if such discharge is necessary): The Contractor must prepare a written plan documenting the best management practices that will be employed to prevent sediment, construction chemicals or other materials from being introduced to excavation dewatering discharges. The NREL EHS Office must approve the discharge plan prior to commencement of excavation dewatering.

G. Waterline, Fire Hydrant, and Fire System Pipeline Testing and Flushing Plans (if such activities are conducted): Potable water and disinfection chemicals used for waterline, fire hydrant, and fire system pipeline flushing may not be discharged directly to the storm drain system, including curb and gutter, or to locations where it will discharge directly to a waters of the U.S. When flushing of systems using potable water and/or disinfection chemicals is required, the Contractor must submit a flushing plan to be reviewed and approved by the NREL EHS Office prior to performing the flushing work.

H. Allowable Non-Stormwater Discharge Plan (if such discharges are generated): Non-stormwater discharges which may be directed to the storm drain system, as allowed by the EPA CGP, include:

1. Discharges from emergency fire-fighting activities
2. Landscape irrigation
3. Water used to wash vehicles and equipment, provided that there are no soaps, solvents or detergents, or grease/oils in the wash water
4. Water used to control dust
5. External building washdown that does not use detergents

6. Pavement wash waters provided spills or leaks of toxic or hazardous materials have not occurred (unless all spill material has been removed) and where detergents are not used. Pavement wash water may not be directed to any surface water, storm drain inlet, or stormwater conveyance, unless the conveyance is connected to a sediment basin, sediment trap, or similarly effective control
7. Uncontaminated air conditioning or compressor condensate
8. Uncontaminated, non-turbid discharges of groundwater or spring water
9. Foundation or footing drains where flows are not contaminated with process materials such as solvents or contaminated groundwater, and
10. Construction dewatering water that has been treated by an appropriate control as identified in the EPA CGP Part 1.2.d and part 2.1.3.4.

I. Contractor shall minimize these discharges to the maximum extent practicable (with the exception of discharges from emergency fire-fighting activities). When a discharge is necessary, the Contractor must submit a discharge plan to the NREL EHS Office for review and approval prior to the activity being performed.

1.8 WARRANTY

A. Contractor is responsible for achieving a vegetative cover equivalent to 70 percent of the predisturbance cover (as identified in the Pre-Disturbance Vegetation Assessment) at the conclusion of the one-year warranty period. Exceptions to this requirement may be made at the discretion of the NREL EHS Office and the Project Manager.

B. Contractor must stabilize the seeded or planted areas with non-vegetative erosion controls that provide cover for at least three years without requiring active maintenance during that period.

PART 2 - EXECUTION

2.1 APPLICABILITY

A. Applicable to NREL NWTC and STM Campuses Only. Stormwater permitting at other NREL locations must follow CDPHE and/or local jurisdiction requirements.

2.2 EPA CONSTRUCTION GENERAL PERMIT COVERAGE

A. Notice of Intent: NREL, the Department of Energy (DOE), and the Contractor must file a NOI on the EPA's electronic eNOI website for all projects that disturb greater than one acre or that disturb less than one acre but that are part of a larger common plan of development. Prior to submittal to the EPA, a draft NOI must first be reviewed and approved by the NREL EHS Office.

B. Earth disturbing activities may not begin until 14 days after all parties (DOE, NREL and the Contractor) have received notification from the EPA acknowledging receipt of the NOIs. Earth disturbing activities may be delayed beyond this if the EPA provides notification that authorization has been delayed or denied.

C. Stormwater Pollution Prevention Plan (SWPPP):

1. The Contractor must develop a SWPPP using the SWPPP template included in Attachment 'A' – Section 013543.01 prior to filing a NOI on the EPA's eNOI website.
2. The SWPPP must be reviewed and accepted by the NREL EHS Office prior to filing the NOI on the EPA's eNOI website.

3. The Contractor must sign and certify the SWPPP per EPA CGP signatory requirements (Appendix I.11 of the EPA CGP).
4. The Contractor must keep the SWPPP on site at all times and comply with EPA CGP general and jobsite posting requirements.
5. As part of the SWPPP document, the Contractor must develop a Site-Specific Erosion and Sediment Control Plan that graphically illustrates the types and locations of construction activities that will occur, the limits of construction, construction phasing, building/structure footprint, paved/gravel area locations, stormwater construction BMPs and pollution prevention practices, direction of stormwater flow across the project site, locations where stormwater leaves the site, and other elements required by Section 7.2.6 of the EPA CGP.
6. Contractor shall follow specific requirements for the selection, design, installation and maintenance of construction stormwater BMPs, including pollution prevention practices, as identified in Section 31 25 00.
7. The Contractor shall modify the SWPPP to reflect current site conditions.
8. Contractor must provide paper and/or electronic copies of all SWPPP updates and modifications to the NREL EHS Office within 24 hours.

D. Other Required Plans

1. Prior to construction, Contractor shall submit the Pre-Disturbance Vegetative Cover Assessment to NREL EHS Office for review and acceptance.
2. As construction proceeds, Contractor shall submit to the NREL EHS Office for review and approval the following plans when applicable to the construction project:
   a. Pesticide/Herbicide Application Plan
   b. Waterline, Fire Hydrant, and Fire System Pipeline Testing and Flushing Plans
   c. Allowable Non-Stormwater Discharge Plan
   d. Waste Management Plan (must comply with the EPA CGP).

E. Training

1. All Personnel.
   a. Contractor shall provide stormwater management awareness training to all personnel working onsite. Such training shall include the types and locations of stormwater erosion and sediment controls on the project site, the purpose and proper functioning of the controls, and who to contact in the event of malfunction or failure of the controls. In addition, training must include identification of pollution prevention practices (e.g. good housekeeping, secondary containment of chemicals and potential pollutants, fueling practices, etc.) required to be followed by all onsite personnel.
   b. Stormwater training acknowledgement forms must be signed by all onsite workers and maintained in the SWPPP.
2. SWPPP Team Members.
   a. Persons responsible for stormwater management must be qualified as defined in the EPA CGP (i.e. knowledgeable in the principles and practices of erosion and sediment controls and pollution prevention, possess the skills to assess conditions at the construction site that could impact stormwater quality, and possess the skills to assess the effectiveness of any stormwater control selected and installed to meet the requirements of the EPA CGP.)

b. Contractor shall provide all SWPPP team members as identified in the project SWPPP with training necessary to conduct inspections, record applicable findings and take corrective actions.

F. Inspections. Refer to Section 31 25 00.

G. Corrective Actions (Refer to Section 31 25 00).

H. Stabilization

1. Temporary Stabilization. If construction activities temporarily cease on a construction site or portion of a construction site and are not scheduled to resume in that location for 14 or more days, Contractor must provide temporary stabilization measures. These measures, among which include mulch applied with tackifier, erosion control blankets, or temporary seeding, must be put in place as soon as practicable, but no later than the end of the next work day, following the day when earth-disturbing activities have temporarily or permanently ceased. This requirement also applies to stockpiles that will remain inactive for 14 or more days. Temporary stabilization must be completed no later than 14 calendar days after initiation of stabilization measures.

2. Final Stabilization. Contractor shall initiate stabilization activities no later than the end of the next work day following the day when earth-disturbing activities have permanently ceased on all or a portion of the construction site. Final stabilization must be completed within 14 days of the end of construction activities on all or a portion of the construction site, unless specifically allowed per the EPA CGP Part 2.2.1.3.

3. Stabilization Criteria. Contractor is responsible for achieving a vegetative cover equivalent to 70 percent of the predisturbance cover (as identified in the Pre-Disturbance Vegetation Assessment) at the conclusion of the one-year warranty period. Exceptions to this requirement may be made at the discretion of the NREL EHS Office and the Project Manager. Contractor must stabilize the seeded or planted areas with non-vegetative erosion controls that provide cover for at least three years without requiring active maintenance during that period.

I. Permit Termination

1. Contractors may terminate their permit coverage by transferring control of all areas of the site to NREL and/or DOE only under the conditions identified below:

a. Final stabilization criteria, as defined in this Section and in Part 2.2.2 of the EPA CGP, have been met in areas that were disturbed and over which the Contractor had control during construction.

b. The NREL EHS Office, Project Manager, Building Area Engineer and/or Site Operations Office have accepted the non-vegetative and vegetative stabilization measures implemented at the project site.

c. Temporary sediment basins have been removed prior to final grading and revegetation.

d. Permanent basins have been cleaned of accumulated debris and excess sediment and revegetated or otherwise stabilized. Revegetation of permanent sediment basins have been completed within 14 days of the completion of construction.

e. Storm drains, pipelines and other drainage conveyances that have received sediment from the construction site have been cleaned at the conclusion of construction activities.

f. All construction materials, waste and waste handling devices, vehicles and equipment used during construction have been removed.

g. All stormwater controls installed and maintained during construction have been removed, except those intended for backup erosion control protection, for long term use or that are biodegradable.

h. All potential pollutants and pollutant-generating activities associated with construction have been concluded.

2. Subcontractor has submitted to the NREL EHS Office the following:

a. An updated electronic file (Microsoft Word) and paper copy of the SWPPP. All tables must be completed and contact information must be updated

b. An updated electronic file (Adobe) and paper copy of the Site-Specific Erosion and Sediment Control Plan which reflects final stabilization measures and BMPs left in place during the restoration/warranty period

c. An updated electronic file (Microsoft Word) and paper copy of the inspection report form which reflects the final stabilization measures and BMPs left in place during the restoration/warranty period

d. A copy of the EPA NOT documentation.

J. Recordkeeping

1. Contractor must ensure that the following records are included in the SWPPP from project initiation through final site stabilization and that copies of these records are provided to the NREL EHS Office.

a. Data and references to sources used to complete the NOI

b. Signed and certified NOI and NOT

c. EPA acknowledgement of the NOI and NOT

d. Changes made to the site-specific SWPPP document and site-specific erosion and sediment control plan

e. Log identifying dates associated with major phases of construction, major grading activities, temporary or permanent termination of construction activities, when stabilization measures are initiated and when final stabilization occurs. A blank log form is included in appendix D of the SWPPP template found in Attachment 'A' – Section 013543.01 which is available in electronic format from NREL.

f. Site worker and subcontractor training data

g. Inspection reports, including corrective actions taken.

2. Per the EPA CGP, Contractor must keep these records for at least three years following permit termination or general permit expiration.

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 Society

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 014550
TESTING LABORATORY SERVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Cooperate with the Owner's selected testing agency and all others responsible for testing and inspecting the Work.
2. Provide such other testing and inspecting as are specified to be furnished by the Contractor in this Section and/or elsewhere in the Contract Documents.

B. Related Sections

1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions of these Specifications.
2. Requirements for testing may be described in various Sections of these Specifications.
3. Where no testing requirements are described, but the Owner decides that testing is required, the Owner may require such testing to be performed under current pertinent standards for testing. Payment for such testing will be made as described in this Section.

C. Work not included:

1. The Owner will select a prequalified independent testing laboratory.
2. Payment for initial services of the testing laboratory as further described in Article 2.1 of this Section.
3. Owner anticipates performing testing/inspection services for, but not limited to, the following portions of the work:
   a. Earthwork
   b. Asphalt
   c. Concrete
   d. Aggregate base

1.2 SUBMITTALS

A. Promptly process and distribute required copies of test reports and related instruments to assure necessary retesting and replacement of materials with the least possible delay in progress of the work.

1.3 QUALITY ASSURANCE

A. The testing laboratory will be qualified to the Owner's approval in accordance with ASTM E329.

B. Testing, when required, will be in accordance with all pertinent codes and regulations, and with selected standards of the American Society for Testing and Materials.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Payment for Testing

1. The Owner will pay for initial testing services requested by the Owner.
2. When initial tests indicate non-compliance with the Contract Documents, the costs of initial tests associated with the non-compliance will be deducted by the Owner from the Contract Sum.

3. When initial tests indicate non-compliance with the Contract Documents, subsequent retesting occasioned by the non-compliance shall be performed by the same testing agency, and costs thereof will be deducted by the Owner from the Contract Sum.

B. Code Compliance Testing

1. Inspections and tests required by codes and ordinances, or by a plan approval authority, shall be the responsibility of, and shall be paid by the Contractor, unless otherwise provided in the Contract Documents.

C. Contractor's Convenience Testing

1. Inspecting and testing performed exclusively for the Contractor's convenience shall be the sole responsibility of the Contractor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Representatives of the testing laboratory shall have access to the Work at all times and at all locations where the Work is in progress. Provide facilities for such access to enable the laboratory to perform its functions properly.

3.2 PREPARATION

A. All specimens and samples for testing, unless otherwise provided in the Contract Documents, shall be taken by the testing personnel. All sampling equipment and personnel will be provided by the testing laboratory. All deliveries of specimens and samples to the testing laboratory will be performed by the testing laboratory.

3.3 FIELD QUALITY CONTROL

A. Provide and maintain an effective Contractor Quality Control (CQC) program and perform sufficient quality control inspections and tests of all items of work, including those of subcontractors, and material fabricators to ensure the compliance with Contract Documents. Furnish appropriate facilities, instruments, and testing devices required for performance of the quality control function. Controls must be adequate to cover construction operations and be keyed to the construction sequence.

3.4 SCHEDULES

A. By advance discussion with the testing laboratory selected by the Owner, determine the time required for the laboratory to perform its tests and to issue each of its findings.

B. Provide all required time within the construction schedule.

C. When changes of construction schedule are necessary during construction, coordinate all such changes with the testing laboratory as required.

D. When the testing laboratory is ready to test according to the established schedule, but is prevented from testing or taking specimens due to incompleteness of the Work, all extra charges for testing attributable to the delay may be back-charged to the Contractor and shall not be borne by the Owner.

END OF SECTION

SECTION 014560
UTILTIY LOCATING AND MARKING SERVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Coordinate and cooperate with the Owner's selected Subsurface Utility Engineering agency and all others responsible for locating public and private utilities on the NREL campuses (STM and NWTC) including all facilities and buildings.
2. Provide such utility locating, marking, and mapping services as specified to be furnished by the Contractor in this Section and/or elsewhere in the Contract Documents.
3. Contractor is responsible to ensure that all required subsurface utility investigations, locating, marking, and mapping is completed per plans and specifications.

B. Related Sections

1. Section 330526 - Underground Utility Marking.
2. Requirements for Utility Locating and Marking services may be described in various Sections of these Specifications.

C. Subsurface Utility Engineering Services

1. The Owner has a separate subcontract with Site Wise (303-650-8680) for subsurface utility engineering services as provided herein.
2. Public Underground Locates – The subcontractor is responsible for calling (811) and overseeing all Public Underground Locates in the construction area prior to construction. The Subcontractor is also responsible for any excavation details or specifications that the Public Utility Company requires. NREL will assist with public underground locate access.
3. Private Underground Locates – After the public underground locates have occurred the Subcontractor is responsible for coordinating all private underground locates prior to construction. NREL has a separate subcontract with Site Wise (303-650-8680) for private underground locates.
    a. The subcontractor shall use NREL's service agreement partner SiteWise for all utility engineering services and locating services including potholing and subsurface boring.
    b. Subcontractor shall be responsible for notifying SiteWise as needed.
    c. SiteWise shall perform the following services for the subcontractor:
        1) Perform 2 forms of utility locate (including potholing) for each utility for all outside subsurface locates.
        2) Perform 2 forms of utility locate for each inside utility including walls, ceilings and floors.
        3) Provide a detailed electronic and paper field survey with GPS (with a minimum of 25% over survey) per NREL's requirements.
        4) Create/update NREL record site drawings & point maps utilizing NREL's/SiteWise's document control protocol.
        5) Fully manage NRELs 3M marker ball program. Provide, program, and document all 3M permanent marker system components per NREL document requirements and specifications.
        6) Immediately remobilize to assist NREL and the subcontractor to assist in investigation of un-located discovered utilities or if utilities are hit during construction

D. Underground Construction

1. The Subcontractor is required to expose all existing underground utilities where new construction crosses existing underground utilities using a water jet vacuum system before any mechanized excavation will be allowed. The subcontractor shall use NREL's service agreement partner SiteWise for exposing existing underground utilities using a water jet system where required.
2. Prior to performing any excavation within five (5) feet of underground power line (including water jet vacuuming), subcontractor must comply with NREL lockout/tagout procedures.
3. Lockout/Tagout of some underground power lines may need to be performed after hours or on weekends depending on the critical nature of the power lines.
4. Subcontractor shall coordinate with NREL EHS on all lockout/tagouts.
5. Contractor shall be responsible to coordinate with by the Owner's Subsurface Utility Engineering service provider, Site Wise, to ensure that all existing underground utilities exposed by construction activities are located and properly marked.

1.2 SUBMITTALS –NOT USED

1.3 QUALITY ASSURANCE

A. The Owner's Subsurface Utility Engineering service provider, Site Wise, will verify all public utility locates as part of the private utility locates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Payment for Testing

1. The Owner will pay for subsurface utility engineering services required by the plans and specifications.
2. Contractor is responsible for any costs related to charges for additional site visits due to failure of Contractor to properly execute its responsibilities as defined herein.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Representatives of the Owner's Subsurface Utility Engineering service provider, Site Wise, shall have access to the Work at all times and at all locations where the Work is in progress. Provide facilities for such access to enable Site Wise to perform its functions properly.

3.2 PREPARATION

A. The subcontractor is responsible for calling (811) and overseeing all Public Underground Locates in the construction area prior to requesting the Subsurface Utility Engineering service provider, Site Wise, to perform private utility locates. The Subcontractor is also responsible for any excavation details or specifications that the Public Utility Company requires. NREL will assist with public underground locate access.

3.3 SCHEDULES

A. By advance discussion with the Owner's Subsurface Utility Engineering service provider, Site Wise, determine the time required for Site Wise to perform its locates and marker ball installations.

B. Provide all required time within the construction schedule.

C. When changes of construction schedule are necessary during construction, coordinate all such changes with the Site Wise as required.

D. When Site Wise is ready to perform its work according to the established schedule, but is prevented from such due to incompleteness of the Work, all extra charges attributable to the delay may be back-charged to the Contractor and shall not be borne by the Owner.

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. 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.

END OF SECTION

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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. Clean dimensional wood, pallet wood
   c. Plywood, OSB, and particleboard
   d. Concrete
   e. Bricks
   f. Concrete Masonry Units (CMUs)
   g. Asphalt roofing shingles
   h. Cardboard, paper, packaging
   i. Asphalt roofing shingles
   j. Metals
   k. Gypsum drywall (unpainted)
   l. Paint
   m. Glass
   n. Plastics

o. Carpet and pad

p. 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. (see form provided) 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.

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 015450
FIELD ENGINEERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Contractor to provide and pay for field engineering services required for Project.
2. Contractor to provide and pay for any other professional engineering services specified or required to execute Contractor's construction methods.

B. Related Sections

1. Conditions of the Contract
2. Section 011000 - Summary of Work
3. Section 017800 - Project Record Documents

1.2 REFERENCES

A. Existing basic horizontal and vertical control points for the Project are those designated on drawings.

B. Locate and protect control points prior to starting work, and preserve all permanent reference points during construction. Make no changes or relocations without prior written notice to the Owner. Replace project control points which may be lost or destroyed. Establish replacements based on original control.

1.3 SUBMITTALS

A. Submit name and address of Surveyor or Professional Engineer to Owner.

B. On request of Owners Representative submit documentation to verify accuracy of field engineering work.

C. Submit certificate signed by registered engineer or surveyor certifying that elevations and locations of improvements are in conformance, or nonconformance, with Contract Documents.

1.4 QUALITY ASSURANCE

A. Field engineering to be performed by qualified engineer acceptable to Contractor and Owner, licensed in the State of Colorado.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 ERECTION INSTALLATION APPLICATION

A. Establish permanent bench marks as required. Record location, with horizontal and vertical data, on Project Record Documents.

B. Establish lines and levels, locate and lay out, by instrumentation and similar appropriate means. Provide controlling lines and levels required for mechanical and electrical trades.

C. From time to time, verify layouts by same methods.

D. Maintain a complete, accurate log of all control and survey work as it progresses.

END OF SECTION

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.

1.6 TESTING AND INSPECTION

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

1.7 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.

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

f. 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. 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.

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, 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.

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

l. 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 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 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 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.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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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.

END OF SECTION

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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, 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. Mechanical Systems: Divisions 22 and 23

   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 017300 - 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 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 019113
GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. This Section includes a general overview of the requirements and procedures for commissioning of the building systems. The systems installed under Divisions 22, 23, and26, as well as certain pieces of equipment provided under other Divisions that connect to or interface with the systems of Divisions 22, 23, and 26, will be evaluated, started, and tested (commissioned) to ensure that each performs per the intent of the design and/or representations made relative to performance, efficiency, and suitability for application in this project.

2. Owner will employ an independent Commissioning Agent (CA). The CA is an independent and knowledgeable third party, hired to verify that the systems work as intended. The CA will inform the Owner, Architect, and Contractor of the results of the commissioning, and provide suggestions, as necessary, to correct deficiencies in observed performance or installation.

3. The CA will be employed directly by the Owner to perform commissioning duties. Division 22, Section “Commissioning of Plumbing”, Division 23 Section ”Commissioning of HVAC”, and Division 26 Section ”Commissioning of Electrical Systems”, outline the specific commissioning responsibilities of the Subcontractor for that division, and also obligate the General Contractor to coordinate and manage the commissioning responsibilities of those subcontractors.

4. Refer to Specification Divisions 22, 23 and 26 and the referenced Commissioning Plan for systems and equipment to be commissioned.

1.2 REFERENCES

A. Project Commissioning Plan

1. A separate document, titled “Project Commissioning Plan” describes detailed requirements for the systems commissioning work. The Commissioning Plan shall be considered integral with these specifications, and a part of the project manual and construction Contract Documents.

2. The contractor shall become thoroughly knowledgeable of the requirements of the Commissioning Plan, all project specifications, and the project drawings, and shall coordinate the work of all trades in the provision of the commissioning services.

B. Project Specifications

1. Various sections of the project specifications require equipment start-up, testing, and adjusting services. Requirements for start-up, testing, and adjusting services specified in the 220000, 230000, and 260000 series sections of these specifications are intended to be provided in coordination with the commissioning services and are not intended to duplicate services. The contractor shall coordinate the work required by individual specification sections with the commissioning services requirements specified herein.

2. Where individual testing, adjusting, or related services are required in the project specifications and not specifically required by this commissioning specification, or the Project Commissioning Plan, the specified services shall be provided and copies of documentation, as required by those specifications, shall be attached to the related sections of the completed project commissioning manual, and indexed for future reference.

3. Where Owner training or educational services are required and specified in Divisions 22, 23, and 26 of the specification, these services are intended to be provided in addition to the training and educational services specified herein and in the Project Commissioning Plan.

1.3 CONTRACTOR'S RESPONSIBILITY

A. Cooperate with the CA's personnel, provide access to work, and provide adequate time in the work for commissioning tasks.

B. Furnish copies of all shop drawings, manufacturers' literature, maintenance information, or other information as may be requested.

C. Provide qualified personnel for assistance to complete the commissioning tests, including seasonal testing. It is the contractor's responsibility to execute the functional test procedures provided by the CA and demonstrate the proper operation of equipment to be commissioned to the CA.

D. Provide training with the assistance of the CA as outlined in Divisions 22, 23, and26.

E. Provide to the CA all proprietary test equipment required by manufacturers to test their equipment.

F. Furnish all proprietary testing equipment required by manufacturers to test their equipment.

G. Provide casual labor and facilities:

1. To provide access to work to be tested.

H. Failed Tests: Should any functional performance test, or any part of a functional performance test fail and require retesting:

1. Owner will compensate the CA for additional testing.
2. Owner will deduct the amount of such compensation from the final payment to the Contractor.

1.4 COMMISSIONING AGENT'S DUTIES

A. Cooperate with Architect and Contractor; provide qualified personnel to witness appropriate tests when scheduled.

B. Promptly notify Architect and Contractor of irregularities or deficiencies in work which are observed during performance of services.

C. Verify testing of all systems to be commissioned as defined in the Commissioning Plan and the written functional test procedures.

D. CA is not authorized to:

1. Release, revoke, alter, or expand requirements of Contract Documents.
2. Approve or accept any portion of work.
3. Perform any duties of the Contractor.
4. Stop any portion of the work.
5. Issue or accept Change Orders.

1.5 TRAINING AND EDUCATION

A. Refer to individual mechanical and electrical equipment sections and the Commissioning Plan for formalized training requirements.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION – NOT USED

END OF SECTION

SECTION 051200
STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Structural steel framing and support members complete with required braces, connection plates, welds, washers, bolts, nuts, shims, anchor bolts, and templates.
2. Base plates and cap plates.
3. Erecting, connecting, field welding, and adjusting for plumb and level.
4. All other work normally related to the above or specified under this section.

B. Related Sections

1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Condition, and Sections in Division 1 of these Specifications.
2. Section 014550 - Testing Laboratory Services

1.2 SUBMITTALS

A. Comply with pertinent provisions of Section 013300.

B. Product data:

1. Within 35 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
   a. Sufficient technical data to demonstrate compliance with the specified requirements.
   b. Complete Shop Drawings showing all members, proposed cuts, connections, camber, holes, and similar data.

1.3 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Perform welding with electric arc process and in accordance with AWS "Code for Arc and Gas Welding in Building Construction."

C. In addition to complying with pertinent codes and regulations, comply with:

1. AISC "Specification for Design, Fabrication, and Erection of Structural Steel for Buildings"
2. AISC "Code of Standard Practice"
3. AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts."

1.4 DELIVERY, STORAGE AND PROTECTION

A. Comply with pertinent provisions of Section 016000

B. Delivery and Storage

1. Deliver materials to the job site properly marked to identify the location for which they are intended.
2. Use markings corresponding to markings shown on the approved shop drawings.

3. Store in a manner to maintain identification and prevent damage, off the ground, using pallets or other supports, and to permit easy access for inspection.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Rolled steel plates, bars, and channels:

1. Comply with ASTM A36.

B. Rolled steel wide flange beams:

1. Comply with ASTM A992.

C. Rolled steel hollow structural sections:

1. Comply with ASTM A500, grade B.

D. Machine Bolts:

1. Comply with ASTM A307, grade A, and ANSI B18.2, with square and/or hexagonal heads as selected by the Contractor.

E. High strength bolts:

1. Comply with ASTM A325, type F or N as indicated on Structural drawings.
2. All bolts shall conform to the "Specifications for Structural Joints using ASTM A325 or A490 bolts" in the AISC manual for steel construction.
3. Bolts shall be tension control (knock off) type or approved equal, to facilitate visual verification of proper installation.

F. Arc welding electrodes:

1. Comply with AWS Requirements.

G. Primer:

1. Use "1099 Tnemec Primer" or
2. "Rustoleum number 5769 Primer."

H. Other Material:

1. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Owner.

2.2 FABRICATION

A. Shop fabrication and assembly

1. Fabricate items of structural steel in accordance with AISC specifications and as shown on the approved Shop Drawings.
2. Where finishing is required, complete the assembly, including welding of units, before start of finishing.
3. Provide finish surfaces of members exposed in the final structure free from markings, burrs, and other defects.

B. Assemble and weld built-up sections by methods that will produce true alignment of axes without warp.

C. Do not flame cut holes or enlarge holes by burning.

D. Shop Painting

1. General

a. Thoroughly clean structural steel, removing all loose mill scale, grease, dirt, and foreign matter by scraping or sandblasting.

b. Apply the specified paint to a dry film thickness not less than 1.5 mils.

2. Do not paint:

a. Contact surfaces of high strength bolted members;

b. Steel scheduled to be concealed, or scheduled to be in contact with concrete.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the areas and conditions under which work of this Section will be performed.

1. Correct conditions detrimental to timely and proper completion of Work.

2. Do not proceed until unsatisfactory conditions are corrected.

3.2 ERECTION INSTALLATION APPLICATION

A. Surveys

1. Establish permanent bench marks necessary for accurate erection of structural steel.

2. Check elevations of concrete surfaces, and locations of anchor bolts and similar items, before erection proceeds.

B. Temporary shoring and bracing

1. Provide temporary shoring and bracing members with connections of sufficient strength to bear imposed loads.

2. Provide temporary guy lines to achieve proper alignment of the structure as erection proceeds.

3. Remove temporary connections and members when permanent members are in place and final connections are made.

C. Anchor bolts

1. Install anchor bolts and other connectors required for securing structural steel to adjacent work.

2. Provide templates and other devices as needed for presetting bolts and other anchors to accurate locations.

D. Setting bases and bearing plates

1. Clean concrete bearing surfaces free from bond-reducing materials, and the roughen to improve bond to surface.

2. Clean the bottom surface of base and bearing plates.

3. Set loose and attached base plates and bearing plate for structural members in wedges or other adjusting devices.
4. Tighten anchor bolts after supported members have been positioned and plumbed.
5. Do not remove wedges or shims but, if protruding, cut off flush with edge of the base or bearing plate prior to packing with grout.
6. Pack grout solidly between bearing surfaces and bases or plates to assure that no voids remain.
7. Finish exposed surfaces, protect installed materials, and allow to cure in strict compliance as approved by the Owner.

E. Field assembly

1. Set structural members accurately to the lines and elevations indicated.
2. Align and adjust the members forming part of a complete frame or structure before fastening permanently.
3. Clean the bearing surfaces and other surfaces that will be in permanent contact before assembly.
4. Adjust as required to compensate for discrepancies in elevation and alignment.
5. Level and plumb individual members of the structure within specified AISC tolerances.
6. Establish required leveling and plumbing measurements on the mean operating temperature of the structure, making allowances for the difference between temperature at time of erection and the mean temperature at which the structure will be when completed and in service.
7. Comply with AISC specification for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to welds.

F. Gas cutting

1. Do not use gas-cutting torches for correcting fabricating errors in structural framing, except on secondary members where acceptable to the Owner.
2. When gas cutting is permitted, finish the gas cut section to a sheared appearance acceptable to the Owner.

G. Painting

1. Secure all required approvals of welding and connections prior to application of field primer.
2. Notify the Owner when the work of this Section is ready to receive primer.
3. Prime coat structural steel and fittings, except galvanized items, which will not be enclosed or concealed in the finished work.
    a. Prepare surfaces by removing loose rust, loose mill scale, and spatter, slag, and flux deposits.
    b. Clean steel in accordance with Steel Structure Painting Council SP-3, "Power Tool Cleaning."
    c. After erection, clean spots and surfaces where paint has been removed, damaged or burned off, and clean filed bolts and other field connections not concealed in the finished Work.
    d. Remove dirt, oil, and grease.
    e. Apply a spot coat of the approved primer.
    f. Do not apply paint to wet, damp, oily, or improperly prepared surfaces.

g. Spray apply the primer, filling joints and corners, and covering surfaces with a smooth unbroken film of at least 1.5 dry mils thickness.

END OF SECTION

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SECTION 220500
COMMON WORK RESULTS FOR PLUMBING

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. Equipment nameplate data requirements.
4. Nonshrink grout for equipment installations.
5. Field-fabricated metal and wood equipment supports.
6. Installation requirements common to equipment specification sections.
7. Mechanical demolition.
8. Cutting and patching.
9. 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. 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. 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. Escutcheons

B. General, all Division 22 sections of the Specifications: Follow the procedures specified in Division 01. Prepare maintenance manuals in accordance with Division 01.

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.

1.7 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 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 SEQUENCING AND SCHEDULING

A. Coordinate plumbing equipment installation with other building components.

B. Arrange for chases, slots, and openings in building structure during progress of construction, to allow for plumbing 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. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

E. Interruption of Plumbing Utilities:

1. The Contractor shall not interrupt any main interior or exterior plumbing 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 equipment will be done by NREL maintenance personnel.

F. 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. Refer to 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. 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. 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. 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. Escutcheons

1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
   a. One Piece, Deep-Pattern Type: Deep-drawn, box shaped brass with polished chrome plated finish.
   b. One-Piece, Cast-Brass Type: With set screw or Split-Casting, Cast-Brass-Type: With concealed hinge and set screw. Finish: Polished chrome plated.
   c. Split-Casting, Cast-Brass Type: With concealed hinge and set screw. Finish: Polished chrome plated.
   d. One-Piece, Floor-Plate Type: Cast-iron floor plate.
   e. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

E. 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.

F. Design Mix: 5000 psi, 28-day compressive strength.

2.2 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.

2.3 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

2.4 Each capacitor shall be internally fused.

2.5 MOTOR CONTROLLER

A. General Motor Controller Characteristics:

1. Single speed and multi-speed motor controllers shall be combination type full NEMA ratedstarters with disconnect switchfor 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.

2.6 IDENTIFICATION

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. 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. 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. 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.
3. Valve tag schedule shall be included in operation and maintenance data.

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 22 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. Verify final equipment locations for roughing in.

18. Refer to equipment specifications in other sections of these specifications for roughing-in requirements.

19. 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. 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. 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 plumbing 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 09.

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. Housekeeping pads under pumps, etc., shall be 3-1/2A inches thick with #4 reinforcing bars 12 inches on center each way unless otherwise noted.

F. 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. Cutting and Patching:

1. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for plumbing 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 plumbing 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 220500

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SECTION 220519
METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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

B. Related Sections: Meters and gauges furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 22 sections of the Specifications.

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 22 section “Common Work Results for Plumbing.”

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 procedures specified in Division 1 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. 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. 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: $\pm$1% of range span or $\pm$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. 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

SECTION 220529
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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 22 Sections of the Specifications.

B. Related Sections:

1. Materials for anchoring piping systems to building structure: Division 5 sections of the Specifications.
2. Roof equipment supports: Division 7 sections of the Specifications.
3. Field-applied painting requirements: Division 9 sections of the Specifications.
4. Expansion joints and expansion loops: Division 22 sections of the Specifications.
5. Vibration-isolation hangers and supports: Division 22 sections of the Specifications.
6. Pipe insulation: Division 22 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. National Fire Protection Association (NFPA). 13 - Installation of Sprinkler Systems.
7. 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 22 Related Sections.

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 22 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. 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 cold and 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

d. Insert material shall be at least as long as the protective shield.

e. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

f. Hangers supporting bare copper pipe shall be copper plated. Field paint all clamps, saddles, and shields.

B. Installation of Pipe Alignment Guides: Install pipe alignment guides on piping that adjoins expansion joints and elsewhere as indicated. Anchor to building structure.

C. 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"

D. Install anchor points per drawings to control pipe movement from thermal expansion.

E. Plastic pipes in hot (over 100°F) environments. Install continuous support to prevent pipes from sagging between hangers.

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. 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 9 Section "Protective Coatings." For galvanized surfaces, clean welds, bolted connections, and abraded areas, and apply cold galvanizing compound to comply with ASTM A780.

END OF SECTION

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SECTION 220553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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, 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. 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 22 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.

2.2 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 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 25 feet on horizontal and vertical pipe runs.

D. For installation of markers for medical gases, refer to Division 22 sections of the Specifications.

E. Apply markers after insulating and/or painting have been completed.

F. 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.

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 EQUIPMENT LABELS

A. Apply equipment labels on a prominent surface of the equipment where they can be readily seen from the operating floor.

3.6 PIPE IDENTIFICATION SCHEDULE

A. Provide pipe identification markers in accordance with the following schedule:

Service	Background Color	Color of Letters
Water:		
Domestic cold water	Green	White
Deionized water	Green	White
Process cold water	Green	White
Industrial Gases:		
Compressed air	Blue	White
Fuels:		
Natural gas	Yellow	Black
Sanitary Drainage:		
Above ground vents and drainage	Green	White
Condensate drainage	Green	White
Indirect waste	Green	White

END OF SECTION

SECTION 220700
PLUMBING 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 plumbing, piping and equipment provided in other Division 22 Specification Sections.

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 and components not to be insulated

a. Vents to atmosphere, discharges from safety and relief valves, except where burn protection for operating personnel dictates.

b. Unions in all locations.

2. Ambient and cold piping systems to be insulated

a. Domestic cold water.

b. First 10 feet of plumbing vents below roof.

c. Drain lines from cooling coil drain pans not located in mechanical equipment rooms.

d. Soil and waste in non air conditioned finished areas or in ceiling cavities over non-air conditioned finished areas.

1.6 SUBMITTALS

A. See requirements in Division 22, “Common Work Results for Plumbing.”

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.

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. See requirements in Division 22, "Common Work Results for Plumbing."

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. C

C. Mineral Wool Insulation

1. Fibrex Insulations Inc.; Owens Corning "Paroc"; Roxul "1200"; Rock Wool Mfg. Co. "Delta PF" or "Delta PC".

D. 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.

E. 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"

F. 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.

G. 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. 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

C. 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)

2. Ambient and Cold Systems: Domestic and Service Cold Water and Sanitary. (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

D. 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.

E.

2.4 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. Restore existing insulation and surface finishes disturbed or damaged during the course of the work to original condition.

S. Provide insulation jackets as specified.

T. 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 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 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. 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 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. Carry the vapor barrier mastic from the outer surface of the insulation to the uninsulated metal parts of the 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. Check the vapor barrier for final dry thickness, continuity, cracks, thin spots, pinholes, etc. Repair unsatisfactory areas.

J. Seal openings on 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 cold piping, maintain vapor barriers continuous over contraction/expansion joints by stepping up and then down back to the pipe insulation.

L. On all 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 22 sections of the Specifications. On

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 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 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 INSULATION PROTECTION APPLICATION

A. Indoor Applications: piping, fittings, and equipment ductwork exposed below 10 feet above a floor or other walking surface.

1. Heated Piping

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 Cold Piping

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 and fittings.

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.

END OF SECTION

SECTION 221116
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes:

1. aboveground domestic water pipes, tubes, fittings, and specialties inside the building.

1.3 REFERENCES

A. American Society of Mechanical Engineers (ASME)

1. B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

B. American National Standards Institute (ANSI)

C. American Society for Testing and Materials (ASTM)

D. American Welding Society (AWS)

1. A5.8 - Specifications for Brazing Filler Metal

E. American Water Works Association (AWWA)

F. National Sanitation Foundation (NSF)

1.4 SUBMITTALS

A. See Division 22 sections of the Specifications.

B. Submit Product Data on the following:

1. Aboveground piping materials.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic, potable domestic water piping and components. Comply with NSF 61 for potable domestic water piping and components.

1.6 WARRANTY

A. Follow the procedure specified in Division 1 of the Specifications.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS - ABOVEGROUND

A. Domestic Hot and Cold Water

Item	Type Joint	Size	Class or Pressure Rating	Material &/or Spec'n	Remarks
Tubing		up through NPS 6	Type L	ASTM B88	Hard drawn Copper
Fittings	Solder	up through NPS 2	Type L	ASME B16.22	Wrought Copper
Unions	Solder	up through NPS 2	150 lb	ASTM B62	Bronze

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. See Division 22 sections of the Specifications.

C. Pitching of Piping

1. Pitch horizontal water 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.

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. 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.
6. The inter-membering of copper and brass with ferrous metal is not permitted.
7. Make the transition between ferrous and nonferrous metal at an exposed and readily accessible location in a water service or at a water heater. Use insulating couplings at these points. (See Paragraph Insulating Couplings.)

3.2 PIPE JOINTING

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.

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.

END OF SECTION 221116

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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 Water Works Association (AWWA):

E. Cast Iron Soil Pipe Institute (CISPI): Cast Iron Soil Pipe and Fittings Handbook.

F. Copper Development Association (CDA): Copper Tube Handbook.

G. 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.

H. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43 - Wrought Stainless Steel Butt-Welding Fittings.

I. 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. 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. 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. 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. 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.

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. Unions: 300 lb. W.O.G. cast bronze or brass flanges.

3. 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.

4. 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.

5. Quick Couplers: Automatic ½" one-way shut-off safety coupler. Foster, Amflo, Quincy.

6. 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. Provide for pipe expansion and seismic braces as required by the contract documents and/or jurisdictional authority.

10. All copper tube and fitting shall be reamed and buffed prior to soldering or brazing.

11. The use of solder containing lead is prohibited.

12. 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.

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 ma 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

SECTION 226119
COMPRESSED AIR EQUIPEMENT FOR LABORATORY AND HEALTHCARE FACILITIES

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. Liquid-ring air compressors.
   2. Rotary-screw air compressors.
   3. Scroll air compressors.
   4. Diaphragm air compressors.
   5. Inlet-air filters.
   6. Desiccant compressed-air dryers.
   7. Compressed-air purification systems.
   8. Compressed-air filter assemblies.

B. Related Requirements:

   1. Section 226400 "Medical Gas Alarms" for compressed-air equipment local alarms.

1.3 DEFINITIONS

A. Actual Air: Air delivered at air-compressor outlet. Flow rate is compressed air delivered and measured in acfm.

B. Laboratory Air Equipment: Compressed-air equipment and accessories for nonmedical laboratory facilities.

C. Medical air equipment includes **medical dental instrument and healthcare laboratory** air compressors and accessories for healthcare facilities.

D. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For air compressors**, compressed-air dryers, and compressed-air purification systems**.

   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. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **Installer and testing agency**.

B. Seismic Qualification Certificates: For air compressors, accessories, and components from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For compressed-air equipment to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Air-Compressor, Inlet-Air Filter Elements: Equal to <**Insert number**> percent of quantity installed, but no fewer than <**Insert number**> units.
2. Belts: [**One**] [**Two**] <**Insert number**> for each belt-driven compressor.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Laboratory Air Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.
2. Medical Air Equipment for Healthcare Facilities: Qualify installers according to ASSE 6010.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the compressed-air equipment testing indicated, that is **a member of the Medical Gas Professional Healthcare Organization or is** an NRTL and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design compressed-air equipment mounting.

B. Seismic Performance: Air compressors **and accessories** shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**

1. The term "withstand" means "the air compressor **and receiver** will remain in place without separation of any parts when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
2. Component Importance Factor: [**1.5**] [**1.0**].
3. <**Insert requirements for Component Amplification Factor and Component Response Modification Factor**>.

2.2 GENERAL REQUIREMENTS FOR AIR COMPRESSORS

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. Comply with NFPA 99, "Health Care Facilities," for compressed-air equipment and accessories for medical compressed-air systems.

C. Comply with UL 544, "Medical and Dental Equipment," for medical compressed-air equipment.

D. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

E. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 120-V ac or less, using integral control power transformer.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.

6. Automatic control switches to **alternate lead-lag air compressors for duplex and sequence lead-lag air compressors for multiplex** air compressors.
7. Instrumentation: Include discharge-air and receiver pressure gages, air-filter maintenance indicator, hour meter, air-compressor discharge-air and coolant temperature gages, and control transformer.
8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.

F. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1. Pressure Rating: At least as high as highest discharge pressure of connected air compressors and bearing appropriate code symbols.
2. Interior Finish: Corrosion-resistant coating.
3. Accessories: Include safety valve, pressure gage,, and pressure regulator.

G. Mounting Frame: Fabricate base and attachment to air compressor and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 TWO-STAGE ELECTRIC RECIPROCATING AIR COMPRESSORS

A. Reciprocating Air Compressors
1. Description: Packaged unit.
2. Air Compressor(s): Twostage, oil-lubricated reciprocating-piston type that will deliver air of quality equal to intake air.

    a. High discharge pressure switch.
    b. Intercooler between stages of two-stage units.

3. Receiver and accessories.

B. Capacities and Characteristics:

1. Compressed-Air Service: Nonmedical laboratory air.
2. Air Compressor(s): One.
3. Standard-Air Capacity of Each Air Compressor: 24.3 scfm free air..
4. Discharge-Air Pressure: 90 psig..
5. Mounting: Freestanding.
6. Motor (Each Air Compressor):

    a. Horsepower: 7.5.

7. Electrical Characteristics:

    a. Volts: 208.
    b. Phase(s): Three.
    c. Hertz: 60.
    d. Full-Load Amperes: 25.2.

8. Receiver:

    a. Orientation: Vertical arrangement.
    b. Capacity: 80 Gallons.
    c. Pressure Rating: 175 maximum.
    d. Drain: Manual. valve.

2.4 COMPRESSED-AIR DRYERS

A. Refrigerant Compressed-Air Dryers:
    1. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 39 deg F, 100-psig air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

B. Capacities and Characteristics:

    1. Standard-Air Capacity of Each Compressed-Air Dryer: 25 scfm free air.
    2. Pressure: 232 psig maximum.
    3. Ambient-Air Temperature: 115 deg F maximum.
    4. Maximum Air-Pressure Drop: 2.90 psig.
    5. Electrical Characteristics:

        a. Volts: 115.
        b. Phase(s): Single.
        c. Hertz: 60 Hz.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean compressed-air equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory airapplications, according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."

3.2 COMPRESSED-AIR EQUIPMENT INSTALLATION

A. General Requirements for Compressed-Air Equipment Installation:

    1. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
    2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
    3. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
    4. Install equipment to allow right of way for piping installed at required slope.
    5. Install the following devices on compressed-air equipment:

a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

B. Nonmedical Laboratory Compressed-Air Equipment Installation:
1. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

a. Anchor air compressors to surface according to manufacturer's written instructions.

3.3 CONNECTIONS

A. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for compressed-air piping specified in Section 226113 "Compressed-Air Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to equipment, allow space for service and maintenance.

D. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.

3.4 IDENTIFICATION

A. Identify nonmedical laboratory compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Identify medical compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment." and with NFPA 99.

END OF SECTION

SECTION 226700
PROCESSED WATER SYSTEMS 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. This Section includes piping, fittings and specialties for deionized water and process cooling water systems.

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. Copper Development Association (CDA): Copper Tube Handbook.

G. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43 - Wrought Stainless Steel Butt-Welding Fittings.

H. National Sanitation Foundation (NSF)

1.4 SUBMITTALS

A. See Division 22 sections of the Specifications.

B. Submit Product Data on the following:

1. Aboveground piping materials

1.5 WARRANTY

A. Follow procedures specified in Division 1 sections of the Specifications.

PART 2 - EXECUTION

2.1 PIPING MATERIALS - ABOVEGROUND

A. Deionized Water

Polyvinyl Chloride (PVC) service limit of 125°F @ 100 psi

Item	Joint Type	Size	Class or Pressure Rating	Material &/or spec	Remarks
Pipe	Solvent Socket	All	Sch 80	PP ASTM D4101	
Fittings	Socket	All	Sch 80	PP ASTM D4101 ASTM D2657	
Flanges	Socket	All	150 lb	Polypro	Viton o-ring 316 Stainless Steel Bolts
Valves	socket	up to 2"		PVC Body	Diaphragm type Teflon diaphragm
	socket or flanged	2 1/2" and larger			
Gaskets		All	1/8 inch thick	EPDM	Full Face Punched Holes
				ASTM A307, Grade B, Threaded, ANSI B1.10/ ANSI B18.2.1, Class 2B Fit	Galv. Carbon Steel Machine Bolts

B. Process Cooling Water

Copper (Cu) Type L Hard Drawn

Item	Type Joint	Size	Class or Rating	Material &/or Spec	Remarks
Tubing		up through NPS 2	Type L	ASTM B88	Hard drawn Copper
Fittings	Solder	up through NPS 2	150 lb	ASME B16.22	Wrought Copper
Unions	Solder	up through NPS 2	150 lb	ASTM B62	Bronze

Gaskets		All	Full face, 1/8 inch thick, 50 to 70 durometer hardness, EPDM	EPDM	
Bolts				ASTM A307 Grade B, Threaded, ANSI B1.10/ANSI B18.2.1, Class 2B Fit	
Primer for Joint Solvent		All	Nibco Purple Primer.		
Solvent Cement		All	Nibco PVC solvent cement. Use heavy- duty industrial grade for Schedule 80 components; use light-duty industrial grade for Schedule 40 components.	ASTM D 2564 ANSI/ASME B31.9, Para. 934.1.2	
Ball Valves		All	PVC Type 1, Grade 1, Teflon ball seal, Viton stem and body seals. Pressure rating 150 psig at 73°F Top entry. Full port opening.		

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.

B. Personnel Protection from Suspended Work: See Division 1 sections of the Specifications for requirements.

C. Pitching of Piping:

1. Pitch horizontal process water 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.

D. Separation of Piping: 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. 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 system, 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 all cut tube ends to the full original bore.

6. The inter-membering of copper and brass with ferrous metal is not permitted.

7. Make the transition between ferrous and nonferrous metal at an exposed and readily accessible location in a water service or at a water heater. Use insulating couplings at these points. (See Paragraph Insulating Couplings.)

3.2 Pipe Jointing

A. Polyvinyl Chloride (PVC)

1. Follow the manufacturer's recommendations in the installation practices, including support types and spacing and compensation for thermal expansion and contraction of the pipe.

2. Cut the pipes square with a wheel type cutter or power saw, then debur the edge of the pipe (inside and outside) according to the manufacture's written instructions.

3. Join pipe and fittings of PVC pipe in accordance with the manufacture's recommendations.

4. Apply solvent cement to clean dry pipe and fittings immediately while primer is still tacky. Apply a heavy even coat of cement to the outside pipe end equal to the depth of the fitting socket. Apply a medium coat to the fitting socket. While both surfaces are still wet with solvent cement, immediately insert the pipe into the fitting socket while rotating the pipe 1/4 turn. Hold assembly for 30 seconds to ensure initial bonding. Check for a continuous bead of cement around the pipe/fitting juncture. If the bead is not continuous, insufficient cement may have been applied and the joint must be cut out, discarded and redone. Wipe excess cement off with a rag.

5. Allow solvent/cement assemblies to cure per manufacturer's set and cure schedule prior to testing.

B. 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 which complies with NSF 61.

C. Reducing Fittings

1. For proper drainage and air elimination, provide eccentric type fittings when decrease in pipe size is necessary. Bushing will not be permitted.

2. For water and other liquid lines, install the top of pipe on a continuous straight line.

END OF SECTION 226700

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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. Equipment nameplate data requirements.
4. Nonshrink grout for equipment installations.
5. Field-fabricated metal and wood equipment supports.
6. Installation requirements common to equipment specification sections.
7. Mechanical demolition.
8. Cutting and patching.
9. 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. 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. 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. 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.

1.7 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 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 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. 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. 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. 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. 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. 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. 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. Verify final equipment locations for roughing in.

18. See equipment specifications in other sections of these specifications for roughing-in requirements.

19. 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. 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. 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. 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. 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

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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. 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. 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. 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

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, ball and plug valves of bubble-tight and dead-end construction.

C. Valve packing containing asbestos material will not be permitted.

D. Equip gate valves with a hexagon gland follower.

E. Equip gate valves with malleable iron hand wheels.

F. Provide manually operated valves, pad-lockable in any position.

G. Provide gate valves which are capable of being packed under pressure when wide open by means of a beveled backseat and bonnet.

H. Provide all gate with four-sided stem to hand-wheel connection with self-locking nut.

2.2 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. 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. 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 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”.

2.4 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. 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.
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. 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. 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.

3. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

4. 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.

5. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

6. 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.

7. 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

   d. Insert material shall be at least as long as the protective shield.

   e. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

   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"

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. 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

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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

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. 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.

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.

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. 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. Proper strainer baskets clean and in place.
    d. Temporary start-up strainer baskets removed.
    e. Service and balance valves open.
    f. Piping systems testing completed and accepted.

1.10 WARRANTY

A. See Division 23 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 strainers for clean screens and proper perforations.

L. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.

O. Examine equipment for installation and for properly operating safety interlocks and controls.

P. 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.

Q. 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. Check for proper sealing of air-handling unit components.

C. 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.

D. 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.

E. 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.

F. Primary-Secondary-Flow Hydronic Systems' Additional Procedures: Balance the primary system crossover flow first, then balance the secondary system.

G. 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.

H. 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.

I. 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.

J. 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.

K. 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.

L. 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.

M. 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. Cooling-Water Flow Rate: 0 to minus 5 percent.

N. 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.

O. 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) Fan drive settings, including settings and percentage of maximum pitch diameter.

6) Inlet vane settings for variable-air-volume systems.

7) Settings for supply-air, static-pressure controller.

8) 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 flow rates.

c. Duct, outlet, and inlet sizes.

d. Pipe and valve sizes and locations.

e. 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. 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.

10. 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).

11. 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.

12. 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.

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.

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) Refrigerant low-pressure-cutoff set point in Btuh.

15) 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.

13. 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.

14. 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.

P. 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

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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. 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**
Condensate	Water	150	2 – 2 hours
Chilled 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

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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 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. Ambient and chilled piping systems to be insulated

a. Chilled water supply and return.

b. Drain lines from drains not located in mechanical equipment rooms.

c. Condenser water (when cooling tower is used for water side economizer only).

2. Ambient and chilled equipment to be insulated.

a. Chilled water tanks including expansion tanks and air separators.

3. Air handling apparatus and ductwork not to be insulated

a. 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.

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. Cellular Glass Insulation

1. Pittsburgh Corning Corporation "Foamglas"; Cell-U-Foam Corp. "Ultra-CUF 1031".

B. Polyisocyanurate (PIR) Unfaced Rigid Insulation

1. The Dow Chemical Company "TRYMER* 2000"; Tarec "Ecopir 33"; Apache "Iso-25".

C. 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.

D. 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"

E. 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.

F. Outdoor Waterproofing

1. Corrugated stucco embossed aluminum jacketing, 0.016-inch thick for pipe and 0.024-inch thick with vapor barrier for equipment.

2.3 PIPE 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 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.

C. 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. Ambient and Chilled Systems: Chilled Water, Glycol Heat Recovery, and Condenser Water. (polyisocyanurate 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

D. 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 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. 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

D. For equipment installed in outdoor locations, increase insulation thickness by one inch. Note: 25/50 flame/smoke requirements not applicable.

2.5 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. 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

D. For equipment installed in outdoor locations, increase insulation by 1-inch. Note: 25/50 flame/smoke requirements not applicable.

2.6 INSULATION PROTECTION

A. Indoor Applications

1. 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 corrugated stucco embossed 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. Restore existing insulation and surface finishes disturbed or damaged during the course of the work to original condition.

R. Provide insulation jackets as specified.

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 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.

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.

E. 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.

F. 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.

G. 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.

H. Check the vapor barrier for final dry thickness, continuity, cracks, thin spots, pinholes, etc. Repair unsatisfactory areas.

I. Seal openings on chilled, ambient and cold piping through insulation vapor tight by applying joint sealer between the protrusion and insulation.

J. 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.

K. 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.

L. 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.

M. 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.

N. 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 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.

3.4 INSULATION PROTECTION APPLICATION

A. Indoor Applications: piping, fittings, equipment and ductwork exposed below 10 feet above a floor or other walking surface.

1. 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. Equipment

   a. Apply metal jacketing for horizontal and vertical 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 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.

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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, 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. ATS Rocky Mountain

   c/o Setpoint Systems Corporation

   8200 S Akron Street, Ste. 117

   Centennial, CO 80112

   (303) 799-1887

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. 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. 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. 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. 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.

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. 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. Current Sensing Relays: Relays shall be provided to monitor status of motor loads. Switch shall have adjustable set point.

i. 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.

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. 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. 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. 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^{o}F (41^{o}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. 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.

b. 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

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SECTION 231123
FACILITY NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Manual gas shutoff valves.
5. Motorized gas valves.
6. Earthquake valves.
7. Pressure regulators.
8. Dielectric unions.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: **100 psig** minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.

C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.3 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Operating-Pressure Rating: 0.5 psig.
3. End Fittings: Zinc-coated steel.
4. Threaded Ends: Comply with ASME B1.20.1.
5. Maximum Length: 72 inches.

B. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: **125 psig**.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

C. PE Ball Valves: Comply with ASME B16.40.
1. Body: PE.
2. Ball: PE.
3. Stem: Acetal.
4. Seats and Seals: Nitrile.
5. Ends: Plain or fusible to match piping.
6. CWP Rating: **80 psig**.
7. Operating Temperature: **Minus 20 to plus 140 deg F**.
8. Operator: Nut or flat head for key operation.
9. Include plastic valve extension.
10. Include tamperproof locking feature for valves where indicated on Drawings.

2.6 DIELECTRIC UNIONS

A. Dielectric Unions:
1. Description:

a. Standard: ASSE 1079.

b. Pressure Rating: **150 psig.**
c. End Connections: Solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 INDOOR PIPING INSTALLATION

A. Comply with **the International Fuel Gas Code** for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

Q. Connect branch piping from top or side of horizontal piping.

R. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment.

S. Do not use natural-gas piping as grounding electrode.

T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

U. Install pressure gage [**downstream**] [**upstream and downstream**] from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.2 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.3 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

F. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameter, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for corrugated stainless-steel tubing, with maximum horizontal spacing and minimum rod diameter, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within **12 inches** of each fitting.

F. Support vertical runs of steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs of corrugated stainless-steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.6 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.7 FIELD QUALITY CONTROL

A. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

B. Natural-gas piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 INDOOR PIPING SCHEDULE

A. Aboveground, branch piping **NPS 1** and smaller shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be **one of** the following:

   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

C. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints.

3.9 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Distribution piping valves for pipe sizes NPS 2 and smaller shall be[**one of**] the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

B. Valves in branch piping for single appliance shall be[**one of**] the following:
   1. Two-piece,full-port, bronze ball valves with bronze trim.

END OF SECTION

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. Chilled-water piping.
2. Condenser-water piping.
3. Glycol cooling-water piping.
4. Makeup-water piping.
5. Condensate-drain piping.
6. Air-vent piping.
7. 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 PIPING MATERIALS - ABOVEGROUND

A. Chilled Water and Glycol.

Item	Type Joint	Size	Class or Pressure Rating	Material &/ or Spec'n.	Remarks
Tubing		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
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 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 aswater 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. 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. 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 gas, gravity condensate, and air lines, install the bottom of the pipe on a continuous straight line.

END OF SECTION

SECTION 232116
HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. 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.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Triple Duty Valves:

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. Bell & Gossett
   b. American Wheatley
   c. Watts
   d. Or Equal
2. Body: Cast Iron conforming to ASTM A126 or Ductile Iron conforming to ASTM A536.
3. Disc: Brass or Bronze conforming to ASTM B584.
4. Seats: EPDM.
5. Stem: Stainless Steel.
6. Spring: Stainless Steel.
7. End Connections: Flanged.
8. Metering Ports: Brass.
9. CWP Rating: 175 PSIG.
10. Maximum Operating Temperature: 225 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install triple duty valves at each pump discharge and elsewhere as required to control flow direction and volume.

C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. See piping installation details on plans for further information on required locations for hydronic piping specialties.

END OF SECTION

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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. 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. Close-Coupled, In-line, Horizontal or Vertical Mounted Pumps

a. Goulds - PIC "2500 Series"

b. Bell & Gossett, ITT - "Series PL"

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.

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, 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 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. 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. 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. Electrical wiring and connections are specified in Division 16 sections of the Specifications.

9. Control wiring and connections are specified in other Division 15 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

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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 Specifications.

1. Product data including details of construction relative to materials, dimensions of individual components, profiles and finishes for the following items:

a. Sealing Materials.

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. 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.

C. 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. 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.

B. Round Supply and Exhaust Fittings Fabrication

1. 90^{o} 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.

        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.

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. Round Gored Elbows Gauges: Same as for nonelbow fittings specified above.

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

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. Manual volume control dampers
3. Actuators
4. Accessories hardware

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. Manual volume control dampers.
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.

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. 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.

B. 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.

C. 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.

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.

3.3 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual dampers is specified in Division 23 sections of the Specification

END OF SECTION

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SECTION 233400
HVAC FANS

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. Centrifugal fans
2. V-belt drives for fans

1.3 REFERENCES

A. American Bearing Manufacturers Association (ABMA)

1. 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. Air Moving and Control Association (AMCA)

1. 99-2411 - Impeller Diameters and Outlet Areas for Tubular Centrifugal Fans and Metric Equivalents.
2. 204 – Balance Quality and Vibration Level for Fans.
3. 210 - Laboratory Methods of Testing Fans for Rating.
4. 211 - Certified Ratings Program - Air Performance.
5. 300 - Reverberant Room Method for Sound Testing Fans.
6. 311 - Certified Sound Ratings Program for Air Moving Devices.
7. Standard Test Code for Air Moving Devices.

C. Air-Conditioning and Refrigeration Institute (ARI)

1. 430 - Standard for Central Station Air-Handling Units.

D. American Society for Testing and Materials (ASTM)

1. B117 – Standard Practice for Operating Salt Spray (Fog) Apparatus.
2. E155 - Reference Radiographs for Examination of Aluminum and Magnesium Castings.

E. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code.
2. 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

F. Underwriters Laboratories Inc. (UL)

1. 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
2. 705 - Power Ventilators.
3. 762 – Power Ventilators for Restaurant Exhaust Appliances.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

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. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Storage and Protection

1. For fans with motors 5 hp and larger that are received and kept in storage or installed in place, provide a manual rotation on a monthly basis or not less than the manufacturer’s recommendations. Maintain a log of these rotations, noting the date and person doing the rotating, and submit the log accompanying the submittal of the Operation and Maintenance Manuals.

1.7 SEQUENCING AND SCHEDULING

A. Coordination

1. Coordinate size and location of structural-steel support members.

2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 23 of the Specifications.

3. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 23 of the Specifications.

B. Extra Materials

1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

a. Belts: One set for each belt-driven unit.

1.8 WARRANTY

A. See Division 23 sections of the Specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Centrifugal Fans - Type CF

1. General

a. Construct fans to conform with the standards of the AMCA, rate fans in full compliance with AMCA 210 and license fans to bear the AMCA seal. Sound test fans in accordance with AMCA 300.

b. Provide fans which have the output, operating characteristics, arrangement, class and accessories as scheduled, and fan volume selection points a minimum of 15 percent greater than the volume at the peak of the pressure volume curve. Provide fans which operate within required noise levels for the particular application. Peak static efficiency: 70 percent minimum.

c. Provide airfoil-bladed, high efficiency design fans with true non-overloading power characteristics, having wheels of welded construction with die-formed, airfoil cross section, double-surface blades continuously welded to hub plate and rims. Fans with wheel diameters less than 24 inches may be plate type blades, backwardly inclined.

d. Provide fans with an operating speed equal to or greater than 90 percent of the AMCA class rpm of the next higher class construction.

2. Housings

a. Provide housings of continuously welded steel construction. Scrolls of fan wheels up to 33 inches in diameter: rotatable for different discharge position. Scrolls of wheels 36 inches in diameter and larger: of fixed discharge position.

b. Provide a removable plug at the lowest point in the scroll. Provide an access door bolted or hinged with appropriate gasket. Steam clean each housing with a chemical degreasing agent; bonderize and prime coat the housing.

3. Structure

a. For wheels up to 33 inches in diameter, provide structure of heavy gage bars and fabricated angles. For larger diameter wheels, provide structure of welded heavy

structural angles and bars. Stream-line inlet cones to provide smooth air flow into the wheel with a minimum of turbulence. On fans with wheels up to 49 inches in diameter, provide spun aluminum cones. On larger sizes, provide mold-formed fiberglass or spun steel cones. Provide OSHA-approved inlet screens on fans with open inlets.

4. Wheels

   a. Class I, Class II or Class III as needed, reinforced as required to meet class specifications, all steel construction with a fixed bore hub. Fabricate wheels up to 22 inches in diameter of die-formed, streamlined profile, single thickness heavy gage steel. Fabricate wheels of larger diameter with double thickness, heavy gage steel streamlined shaped blades. Use continuous smooth welding for wheel fabrication. Double width wheels shall have blades staggered on each side of center plate.

5. Shafts

   a. Fabricate fan shafts of solid one piece carbon steel, AISI C-1040 or 1045, stress proof or stress relieve steel.

   b. Straight shafts: turned, ground, polished to a minimum 16 microinch finish and ring gauged to meet the following tolerances:

      1) Up to 3 inches diameter: plus 0.0006 inch.

      2) 3 inches to 5 inches diameter: plus 0.0000, minus 0.0007 inch.

      3) Over 5 inches diameter: plus 0.0000, minus 0.0015 inch.

   c. Step shafts: turned, ground and polished in the wheel, bearing and sheave mounting areas to a minimum 63 microinch finish. Hydraulically straighten all shafts before and after cutting the keyways to maintain a maximum total indicated runout of 0.002 inch. Minimum first shaft critical speed: 30 percent greater than maximum speed required to meet AMCA class duties.

   d. Supply shaft with matching keyways and keys. Check shafts for straightness after keyways are cut.

6. Bearings

   a. Furnish fans with air handling quality, heavy duty, self aligning, grease lubricated, pillowblock type, roller bearings selected for a minimum L-10 life of 100,000 hours under continuous loading in accordance with ABMA 9, at the maximum operating speed of the fan's AMCA class, the fan operating temperature and horsepower.

   b. Double row spherical roller in a one piece cast iron housing, or a double row spherical roller type in a two piece cast iron pillow block.

   c. Provide bearings with "Zerk" fittings for lubrication. Extend copper grease leads to an accessible location within the housing.

   d. Determine size of bearings by assuming V-belt drive and including belt pull. Provide bearing support which is removable and not an integral part of the housing support structure.

   e. Manufacturer: SKF “Type FAF”, or approved product of Fafnir, or Link-Belt.

7. Drive Arrangement.

a. Provide fans with drive arrangement 3 with fan wheel mounted between the bearings which are supported by the fan housing, and the motor mounted on a separate sliding base.

8. Final Assembly Balancing

a. After final assembly, check vibration levels of fans provided with variable speed drives at all speeds between 25 percent and 100 percent of the units' design rpm. Check vibration at both fan shaft bearings in radial (vertical and horizontal) and axial directions. If, in the judgment of the Architect, excessive vibration is found at any frequency, provide special balancing and structural changes to minimize harmonic vibrations.

9. Manufacturers

a. Howden Fan Co.; Chicago Blower; Avaho Industries, Inc.; New York Blower; Loren Cook; Bayley; Greenheck; Acme; Hartzell; Twin City; or Barry Blower.

B. V-Belt Drives

1. Drives

a. Provide standard-duty, cast steel sheaves, selected to provide 50 percent excess capacity for motors less than 3 horsepower and 25 percent capacity for motors 3 horsepower and larger.

b. Provide sheaves that are statically and dynamically balanced with interchangeable tapered bushings.

c. For single belt drives provide a motor sheave of the adjustable type. Fan and motor sheaves to deliver the required fan speed at the mid-range of the motor sheave adjustment.

d. For multiple belt drives, provide the quick-detachable fixed pitch type sheaves. Employ an adjustable sheave to determine the proper RPM and then install the fixed sheave of the proper diameter. Select the sheaves to deliver the fan speed required to obtain the fan cu. m/s (cfm) and static pressure as required.

e. Provide multiple belts in matched sets and of the oil and heat resistant and static conductive type.

f. Minimum sheave pitch diameters:

1) A Section Belts 3.5 in.

2) B Section Belts 5.4 in.

3) C Section Belts 9.0 in.

4) D Section Belts 13.0 in.

5) E Section Belts 21.6 in.

2. Manufacturer:

a. As manufactured by Browning Div. of EPT, Dodge Div. of Rockwell Automation or T. B. Wood’s Inc.

3. Guards

a. See Division 23 sections of the Specifications for requirements for V-belt drive guards.

PART 3 - EXECUTION

3.1 ERECTION, INSTALLATION AND APPLICATION

A. Install fans level and plumb.

B. Support fans using vibration supports. Vibration- and seismic-control devices are specified in Division 23 of the Specifications.

C. Support suspended units from structure using threaded steel rods and vibration-control devices specified in Division 23 of the Specifications.

1. In seismic zones, restrain support units.

D. Install units with clearances for service and maintenance.

E. Label fans according to requirements specified in Division 23 of the Specifications.

F. Duct installation and connection requirements are specified in other Division 23 sections of the Specifications. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 of the Specifications.

G. Install ducts adjacent to fans to allow service and maintenance.

H. Ground Equipment

1. 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.

3.2 FIELD QUALITY CONTROL

A. Equipment Startup Checks

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Verify lubrication for bearings and other moving parts.

6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

B. Starting Procedures

1. Energize motor and adjust fan to indicated rpm.

2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. See Division 23 sections of the Specifications for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.4 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

2. Review data in maintenance manuals. See Division 23 sections of the Specifications.

3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION

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SECTION 236423.13
AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

C. DDC: Direct digital control.

D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.

E. GFI: Ground fault interrupt.

F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

G. I/O: Input/output.

H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

J. SCCR: Short-circuit current rating.

K. TEAO: Totally enclosed air over.

L. TENV: Totally enclosed nonventilating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates: For certification required in "Quality Assurance" Article.

B. Seismic Qualification Data: Certificates, for water chillers, accessories, and components, from manufacturers.

C. Installation instructions.

D. Source quality-control reports.

E. Startup service reports.

F. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

a. Complete chiller including refrigerant and oil charge.

b. Complete compressor and drive assembly including refrigerant and oil charge.

c. Refrigerant and oil charge.

1) Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.

d. Parts and labor.

2. Warranty Period: Fiveyears from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2. Component Importance Factor: 1.5.

B. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

C. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:

1. Allowable Capacity Tolerance: Zero percent.

D. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.

E. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

F. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

G. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

H. Comply with NFPA 70.

I. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.

J. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.

2. See drawings for equipment served by backup power systems.

3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

K. Outdoor Installations:

1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25 year period with minimal degradation due to exposure to outdoor ambient conditions.

2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30 >-year period.

2.2 MANUFACTURERS

A. MultiStack, LLC?

2.3 MANUFACTURED UNITS

A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.

B. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.

2.4 CABINET

A. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.

B. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.

C. Casing: Galvanized steel.

D. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B117.

2.5 COMPRESSOR-DRIVE ASSEMBLIES

A. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.

2. Operating Speed: Nominal 3600 rpm for 60-Hz applications.

3. Capacity Control: On-off compressor cycling.

    a. Digital compressor unloading is an acceptable alternative to achieve capacity control.

4. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.

    a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.

5. Vibration Isolation: Mount individual compressors on vibration isolators.

    a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

B. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.

2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

C. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

2.6 REFRIGERATION

A. Refrigerant: R-410A. Classified as Safety Group A1 according to ASHRAE 34.

B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

C. Refrigerant Circuit: Each circuit shall include an electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

D. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.

3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.

2.7 EVAPORATOR

A. Shell and Tube:

1. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.

2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

3. Shell Material: Carbon steel.

4. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.

5. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.

6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

B. Brazed Plate:

1. Direct-expansion, single-pass, brazed-plate design.

2. Type 304 or 316 stainless-steel construction.

3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.

4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

5. Inlet Strainer: Factory-furnished, 40 >-mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.

C. Flow Switch: Factory-furnished and -installed, flow switch wired to chiller operating controls.

D. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F

E. Remote-Mounting Kit: Designed for remote field mounting where indicated. Provide kit for field installation.

2.8 AIR-COOLED CONDENSER

A. Coil(s) with integral subcooling on each circuit.

B. Copper Tube with Plate Fin Coils:

1. Construct coils of copper tubes mechanically bonded to aluminum fins.

2. Coating: None

C. Aluminum Microchannel Coils:

1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.

2. Single- or multiple-pass arrangement.

3. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.

D. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

F. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.

G. Fan Guards: Removable steel safety guards with corrosion-resistant coating.

2.9 INSULATION

A. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

2.10 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

C. House in a unit-mounted, NEMA 250, Type 3Renclosure with hinged access door with lock and key or padlock and key.

D. Wiring shall be numbered and color-coded to match wiring diagram.

E. Factory wiring shall be located outside of an enclosure in a metal raceway. Terminal connections shall be made with not more than a 24-inch length of liquidtight conduit.

F. Field power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than [2,000A.

G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

H. Each motor shall have overcurrent protection.

I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

J. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

K. Power Factor Correction: Capacitors to correct power factor to [.90 at full load.

L. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

M. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.

N. Service Receptacle:

1. Unit-mounted, 120-V GFI duplex receptacle.
2. Power receptacle from chiller internal electrical power wiring.

O. Indicate the following for water chiller electrical power supply:

1. Current, phase to phase, for all three phases.
2. Voltage, phase to phase and phase to neutral for all three phases.

3. Three-phase real power (kilowatts).
4. Three-phase reactive power (kilovolt amperes reactive).
5. Power factor.
6. Running log of total power versus time (kilowatt hours).
7. Fault log, with time and date of each.

2.11 CONTROLS

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Chilled-water entering and leaving temperatures.
7. Refrigerant pressures in evaporator and condenser.
8. Saturation temperature in evaporator and condenser.
9. No cooling load condition.
10. Elapsed time meter (compressor run status).
11. Pump status.
12. Antirecycling timer status.
13. Percent of maximum motor amperage.
14. Current-limit set point.
15. Number of compressor starts.
16. Alarm history with retention of operational data before unit shutdown.
17. Superheat.
18.

E. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Capacity control based on evaporator leaving-fluid temperature.
3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.

4. Chilled-water entering and leaving temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on [eturn-water temperature.
5. Current limit and demand limit.
6. Condenser-water temperature.
7. External water chiller emergency stop.
8. Antirecycling timer.
9. Automatic lead-lag switching.
10. Ice-building mode.

F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator pressure or high condenser pressure.
2. Low chilled-water temperature.
3. Refrigerant high pressure.
4. High or low oil pressure.
5. High oil temperature.
6. Loss of chilled-water flow.
7. Loss of condenser-water flow.
8. Control device failure.

G. DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.

1. Hardwired I/O Points:
    a. Monitoring: On/off status, common trouble alarm.
    b. Control: On/off operation, [hilled-water discharge temperature set-point adjustment
2. Communication Interface: ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

H. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway. Make terminal connections with liquidtight or flexible metallic conduit.

2.12 CAPACITIES AND CHARACTERISTICS

A. See Schedule on Drawings

2.13 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.

2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000 -hour salt-spray test according to ASTM B117.

1. Standards:

a. ASTM B117 for salt spray.

b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).

c. ASTM B3359 for cross hatch adhesion of 5B.

2. Application: Spray.

3. Thickness: 1 mil.

4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.14 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

a. Design conditions indicated.

b. AHRI 550/590 part-load points.

2. Allow Owneraccess to place where water chillers are being tested. Notify Owner [14days in advance of testing.

C. Factory test and inspect evaporatoraccording to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 WATER CHILLER INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.

C. Install water chillers on support structure indicated.

D. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to chillers, allow space for service and maintenance.

D. Connect each drain connection with a drain valve, full size of drain connection

3.3 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between chiller control interface and [DC systemfor remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to performstartup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

E. Prepare a written startup report that records results of tests and inspections.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers.Video record the training sessions and provide electronic copy to Owner.

1. Instructor shall be factory trained and certified.
2. Provide not less than eighthours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION

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SECTION 238216.11
HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: **200 psig**

D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.

E. Chilled-Water Coil Capacities and Characteristics:

1. Coil Face Dimensions:
    a. Finned Length: 66 inches.
    b. Finned Width: 18-1/2 inches.
2. Number of Rows: 10.
3. Air Side:
    a. Flow Rate: 7500 cfm.
    b. Finned Area Face Velocity: 390 fpm.
    c. Static Pressure Drop: 0.374 in wg.
    d. Total Capacity: 99.65 MBH
    e. Sensible Capacity: 55.47 MBH.
    f. Entering Dry-Bulb Temperature: 63.30 deg F.
    g. Entering Wet-Bulb Temperature: 60.00 deg F.
    h. Leaving Dry-Bulb Temperature: 55.14 deg F.
    i. Leaving Wet-Bulb Temperature: 55.04 deg F.

4. Water Side:
    a. Flow Rate: 23.00 gpm.
    b. Tube Velocity: 0.91 fps.
    c. Glycol Type: Propylene.
    d. Aqueous Glycol Solution Concentration: 30%
    e. Pressure Drop: 2.17 ft wg.
    f. Entering Temperature: 49.00 deg F.
    g. Leaving Temperature: 58.36 deg F.

2.2 HYDRONIC AIR COILS

A. Description: Coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into the coil fins; self-venting; counterflow design of air to fluid.

B. Tubes:
    1. Material: Copper
    2. Nominal Diameter: Minimum 1/2 inch or 5/8 inch before expanding, selected to provide performance indicated.
    3. Nominal Wall Thickness: As required by performance, minimum thick.
    4. Return Bends: 180-degree bends; materialand nominal diameter to match tubes.
    5. Fluid Velocity at Design Flow Rate:
        a. Maximum: 6 fps .
    6. Features: Cleanable

C. Fins:
    1. Type: Plate.
    2. Materials:
        a. Aluminum: 0.0060 inch thick.
    3. Spacing: Maximum 12 fins per inch.
    4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
    5. Configuration: Fin type as required by performance requirements .
    6. Fin and Tube Joint: silver brazed.

D. Headers:
    1. Material: copper.
    2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced-header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
    3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.

4. Drains: Include low point of supply and return header with a NPS 1/2 drain connection.

5. Vents: Include high point of returnheader with a NPS 1/2 vent connection.

6. Supply and Return Connections: Copperpipe; threade], same end of coil.

7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.

8. Fluid Velocity at Design Flow Rate: Maximum of 6 fps.

E. Casings and Tube Sheets:

1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.

2. Materials:

a. Galvanized steel, ASTM A653/A653M, G90 coating.

F. Top and Bottom Casings:

1. Flange face minimum of 1-1/2 inches; double-flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch (.

2. Thickness:

a. Coils with Fin Length of Up to 72 Inches: Minimum of 16 gauge thick.

G. End Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

2. Flange face minimum of 1-1/2 inches.

3. Thickness: Minimum of 16 gauge thick.

H. Intermediate Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

2. Space intermediate tube sheets a maximum of 48 inches o.c. and locate to provide equal spacing between tube sheet across coil tube length.

3. Flange face minimum of 1/2 inch.

4. Thickness: Minimum of 16 gauge thick.

I. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

J. Hardware: Use hex-head bolts, nuts, and washers constructed of stainless steel.

K. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

1. Manufacturer name, address, telephone number, and website address.

2. Manufacturer model number.

3. Serial number.

4. Manufacturing date.

5. Coil identification (indicated on Drawings).
6. Coil fin length.
7. Coil fin height.
8. Coil weight with fluid/without fluid.
9. Coil casing material and thickness.
10. Coil fin material and thickness.
11. Coil tube material and thickness.
12. Coil header material and thickness.

L. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

M. Coating: Corrosion resistant.

2.3 MATERIALS

A. Aluminum: ASTM B209

B. Copper Tube: ASTM B75/ASTM 75M annealed temper or ASTM B280 drawn temper.

C. Steel:

1. Pipe Connections: ASTM A53/A53M.

D. Corrosion-Resistant Coating: Where indicated on Drawings, coat coils with a corrosion-resistant coating capable of withstanding a 3000 >-hour salt-spray test in accordance with ASTM B117.

1. Standards:
   a. ASTM B117 for salt spray.
   b. ASTM D2794 for minimum impact resistance of 100 in. lb
   c. ASTM D3359 for cross-hatch adhesion of 5B.
2. Application: Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.4 SOURCE QUALITY CONTROL

A. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than 300-psig internal pressure.

B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install stainless steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.

2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.

3. Extend drain pan upstream and downstream from coil face.

4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

END OF SECTION

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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.

C. National Fire Protection Association (NFPA):

1. 70 - National Electrical Code.

1.4 SYSTEM DESCRIPTION

A. Fault Current Analysis and Protective Device Coordination:

1. The Engineer has preformed Fault Current Analysis and Protective Device Coordination in the course of design. The Contractor shall perform a complete fault current analysis, using parameters of the electrical equipment and data from the manufacturer being proposed. The purpose is to verify that equipment ratings are adequate for their fault duty.

a. Perform a complete fault current analysis under the supervision of, and certified by, a registered professional engineer.

b. Use conductor lengths developed from the installation drawings prepared by the Contractor.

c. Include all distribution equipment from the incoming utility company primary service to 120/208 volt panelboards.

d. Document all equipment data, calculation methods, and assumptions used in the analysis.

2. Provide a protective device coordination analysis which indicates that the submitted products provide a selectively coordinated power distribution system with the same or greater level of coordination.
    a. Perform a complete protective device coordination study under the supervision of, and certified by, a registered professional engineer.
    b. Use fault currents as calculated in the fault current analysis.
    c. Include the specific manufacturer, model and catalog number of all renewable parts, such as fuses, so that specific replacement parts can be procured.
    d. Tabulate all protective device ratings, capacities and settings recommended for a selectively coordinated distribution system. Include devices and settings to be used by the utility company.
    e. Include protective device ranges and settings; current transformer ratio; selected ratio tap and range of ratios; fuse rating and speed; and settings of other adjustable parameters.
    f. Draw time-current characteristics of devices on reproducible log-paper. Indicate voltage, current, time value and scale factors.

B. Cable Pulling Calculations:
1. Provide cable-pulling calculations for indicated feeders.
2. Provide dimensioned drawings of actual conduit and cable tray layouts and include a summary table with the following:
    a. Calculated pulling tension and sidewall pressure.
    b. Maximum allowable tension and pressure limits as recommended by cable manufacturer.
    c. Identify cable size, cable type, method of grip, and all assumptions and factors used in the calculations for each feeder.
    d. Identify feeders in a manner consistent with contract documents.

1.5 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 fault current analysis and over-current protective device coordination study within 30 days of switchgear shop drawing approval.
2. Submit results of factory tests two weeks prior to product shipment from factory.
3. Submit results of field tests immediately upon completion of the field test.
4. 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. Power distribution system, including distribution equipment and each conduit and wire size 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. Layout, cabling and circuiting of site electrical systems such as underground duct banks
    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.

1.6 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).

1.7 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”.

1.8 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.

1.9 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.

13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable 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

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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

B. Test Reports: Submit in conformance with related Division 1 Sections of the Specifications, meggar testing results for feeders rated larger than 100A.

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. UL 83 for thermoplastic insulated wires.
2. UL 758 for 221 deg F appliance wiring materials.
3. Fed Spec. J-C 30A.
4. 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

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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. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

B. Ground Cable: All ground cable shall be annealed, concentrically stranded, bare copper. Grounding cable size shall be as shown on the Drawings or as required by the NEC.

C. Bolted Connectors:

1. The bolted type grounding connector shall be made of high copper alloy and manufactured specifically for the particular grounding application. The connector shall be Burndy, O.Z. Gedney, or equal.

D. 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.

E. 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. Individually bond these raceways to the ground bus in the secondary section.

6. 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.

7. Measure ground impedance in accordance with IEEE STD 81 after installation before connection to the remaining grounding system.

8. Low Voltage Grounded System (600V or Less).

a. A low voltage grounded system shall be a system where the local power supply is a transformer with the transformer secondary grounded.

b. The first disconnecting means on the load side of this transformer shall provide the point where the neutral conductor is grounded.

c. The neutral shall be connected to the Equipment Grounding Circuit Conductor only at one point and shall be within the enclosure of the disconnecting means.

d. The Grounding Electrode Conductor or the Equipment Grounding Circuit Conductor shall not be used as the neutral.

9. Shield Grounding:

   a. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicated the shield is to be grounded at both ends.

   b. The grounding point shall be at the control panel or otherwise at the receiving end of the signal carried by the cable.

   c. Termination of shield drain wire shall be on its own terminal screw.

   d. All of these terminal screws shall be jumpered together using manufactured terminal block jumpers.

   e. Connection to the ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

10. Signal Reference Grids and EMF Shielding: Provide connection to electrical system ground per manufacturer's requirements. Comply with the requirements of IEEE STD 1100.

3.2 FIELD QUALITY CONTROL

A. Test in accordance with applicable Division 26 sections of the Specifications.

3.3 ADJUSTING

A. Under the direction of the Engineer the Contractor shall add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the resistance requirements of the Engineer. Additional work performed by the Contractor shall be under a separate contract using documented per unit values for the additional Work.

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, concrete equipment pads, 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 size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. 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

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. Liquidtight Flexible Metallic Conduit: Shall conform to the following applicable standards.

1. UL 360

M. 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.

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. 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.
5. 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. Conduit in Concrete Slab

1. Install conduit between bottom reinforcing steel and top reinforcing steel.
2. For supported floor conditions, separate conduits by not less than three times diameter of largest conduit in grouping to permit proper concrete fill and bond.
3. Install conduit with minimum 1 inch of concrete cover.
4. Do not embed conduit with outside diameter exceeding 1/3 of slab thickness.
5. Do not install conduit greater than 1 inch in concrete slab unless approved.

E. 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.

F. Direct-Buried Conduit:

1. Provide a 3 inch minimum sand bed in bottom of trench prior to installing conduit. Install conduit as specified, with spacing as indicated, on the sand bed, and cover with a minimum of 3 inches of sand. Make conduit joints watertight.
2. Install plastic covered, minimum 0.020 inch thickness, RSC or rigid non-metallic conduit.
3. Provide RSC large-radius sweeps for conduit bends which exceed 30 degrees either horizontally or vertically.
4. Provide rigid steel conduit at risers, within 5 feet of building walls, under roads and at other locations as indicated. Extend rigid steel conduit a minimum of 5 feet beyond edge of roads.
5. Provide conduit adapters for connection of conduit of different materials.
6. For risers, use bends having a minimum radius of 36 inches for 3 inch and larger conduit, and 24 inches for conduit smaller than 3 inch.
7. Do not install conduit until cable pulling calculations have been approved by the Engineer.
8. Clean conduits of foreign material and obstructions, with a mandrel after installation and prior to installation of pull lines and cables.
9. Plug or cap ends of conduits after installation to prevent entry of foreign material.

G. Concrete Encased Conduit or Duct: Coordinate with requirements of Division 2 of the Specifications.

H. 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.

I. 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.

J. 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.

K. 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.

L. 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.

M. 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.

N. 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

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. Disconnect switch.

c. Push buttons, selector switches, indicating lights. (Circuit number and voltage not required on sign).

d. Wireway used as auxiliary gutter tap locations with circuit number of circuit being tapped.

e. 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

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SECTION 260810
ELECTRICAL TESTING

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. The Contractor shall be responsible for furnishing services for the purposes of performing inspections and tests as herein specified. This work may be conducted by the electrical subcontractors and/or independent testing laboratory but shall be performed by qualified personnel. The decision concerning acceptability of the qualifications of the individual and/or firm conducting the tests shall be determined during submittal review in accordance with related Division 1 sections of the Specifications. The term testing laboratory shall unilaterally refer to the firm, subcontractor, etc. approved to conduct the tests.

    a. For the purposes of this Section the individual performing the testing whether the electrical subcontractor, manufacturer's representative or independent testing laboratory shall be referred to as testing laboratory.

    b. The Contractor shall submit a division of responsibilities that shall detail who is responsible for performing each test.

    c. All visual and mechanical inspections shall be conducted by the Contractor and Engineer's representative.

2. The testing laboratory shall provide all material, equipment, power, labor and technical supervision to perform such tests and inspections.

3. It is the intent of these tests to assure that all electrical equipment is operational within industry and manufacturer's tolerances.

4. Upon completion of the tests and inspections noted in these specifications, a label shall be attached to all serviced devices. These labels will indicate date serviced and the service company responsible.

5. The tests and inspections shall determine suitability for continued reliable operation.

6. All tests shall be conducted in the presence of the Engineer or the Engineer's representative.

7. Electrical testing specified herein, and functional testing of all power and controls not tested under the "Instrumentation and Control Specifications" shall be completed before commencement of the 7-day test specified in the "Equipment Testing and Plant Start-up Specifications."

8. The Work may require the Contractor to activate circuits, shutdown circuits and run equipment, make electrical measurements, replace blown fuses, install temporary jumpers, etc.

1.3 REFERENCES

A. National Electrical Testing Association (NETA)

B. Manufacturer's Recommended Test

1.4 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.
5. National Electrical Tester Association.

1.5 SYSTEM DESCRIPTION

A. Specific Scope of Work

1. The following items of equipment shall be tested.
    a. All Wires and Cables.
    b. Motors.
    c. Grounding System.

1.6 SUBMITTALS

A. Shop Drawings

1. The testing laboratory shall submit in conformance with Division 1 sections of the Specifications a complete resume and statement of qualifications detailing their experiences in performing the test specified. This statement shall include:
    a. Corporate history and references.
    b. Resume of individual performing test.
    c. Equipment list and test calibration data.
2. The Contractor shall submit to the Engineer and the testing laboratory in conformance with Division 1 sections of the Specifications complete manufacturers field-testing acceptance testing procedures, as well as expected test results and tolerances for all equipment to be tested.

B. Test Report

1. The test report shall include the following.
    a. Summary of project.
    b. Description of equipment tested.
    c. Description of test.
    d. Test results.
    e. Conclusions and recommendations.
    f. Appendix, including appropriate test forms.
    g. List of test equipment used and calibration date.
2. Furnish three (3) copies of the completed report to the Engineer in conformance with Division 1 sections of the Specifications.

1.7 QUALITY ASSURANCE

A. Regulatory Requirements

1. All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise herein.

   a. National Electrical Code--NEC.

   b. National Electrical Manufacturer's Association--NEMA.

   c. American Society for Testing and Materials--ASTM.

   d. Institute of Electrical and Electronic Engineers--IEEE.

   e. National Electrical Testing Association--NETA.

   f. American National Standards Institute--ANSI.

   g. State and Local Codes and Ordinances.

   h. Insulated Cable Engineers Association--ICEA.

   i. Association of Edison Illuminating Companies--AEIC.

   j. OSHA Part 1910; Subpart S, 1910.308.

   k. National Fire Protection Association--NFPA.

2. All inspections and tests shall utilize the following references.

   a. Project Design Specifications.

   b. Project Design Drawings.

   c. Manufacturer's instruction manuals applicable to each particular apparatus.

1.8 SEQUENCING AND SCHEDULING

A. Division of Responsibility

1. The Contractor shall perform routine insulation resistance, continuity and rotation tests for all distribution and utilization equipment prior and in addition to tests performed by the testing laboratory specified herein.

2. The Contractor shall supply a suitable and stable source of test power to the test laboratory at each test site. The testing laboratory shall specify requirements.

3. The Contractor shall notify the testing laboratory and schedule with the Engineer when equipment becomes available for acceptance tests.

4. The Contractor shall notify the Engineer prior to commencement of any testing.

5. The testing laboratory shall be responsible for implementing all final settings and adjustments on protective devices and tap changers in accordance with Engineers specified values.

6. Any system material or workmanship which is found defective on the basis of acceptance tests shall be reported directly to the ENGINEER.

7. The testing laboratory shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report.

PART 2 - TEST INSTRUMENTS

2.1 TEST INSTRUMENTS TRACEABILITY

A. The testing laboratory shall have a calibration program which maintains all applicable test instrumentation within rated accuracy.

B. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.

C. Instruments shall be calibrated in accordance with the following frequency schedule.

1. Field instruments--6 months maximum.

2. Laboratory instruments--12 months.

3. Leased specialty equipment--12 months. (Where accuracy is guaranteed by lessor).

D. Dated calibration labels shall be visible on all test equipment.

E. Records must be kept up to date which show date and results of all instruments calibrated or tested.

F. An up-to-date instrument calibration instruction and procedure will be maintained for each test instrument.

PART 3 - EXECUTION

3.1 PREPARATION

A. Safety and precautions.

1. Safety practices shall include, but are not limited to the following requirements

a. Occupational Safety and Health Act of 1970-OSHA.

b. Accident Prevention Manual for Industrial Operations, Seventh Edition, National Safety Council, Chapter 4.

c. Applicable State and Local safety operating procedures.

d. NETA Safety/Accident Prevention Program.

e. Owner's safety practices.

f. National Fire Protection Association-NFPA 70E.

2. The testing laboratory shall be solely responsible for safety during all tests.

3. In all cases, work shall not proceed until the testing laboratory, Contractor, and Engineer's field representative have determined that it is safe to do so.

4. The testing laboratory shall have available sufficient protective barriers and warning signs to conduct specified tests safely.

B. Testing requirements prior to commencing the work.

1. All instruments required must be available and in proper operating condition.

2. All dispensable materials such as solvents, rags and brushes required must be provided.

3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment must be available or scheduled.

4. All instruction books, calibration curves or other printed material to cover the electrical devices must be available.

5. Data sheets to record all test results must be available before the work is started.

3.2 TEST PROCEDURES

A. Rotating Machinery

1. Visual and mechanical inspection.
    a. Inspect for physical damage.
    b. Compare equipment nameplate information with single line diagram and report discrepancy.
    c. Inspect for proper anchorage, mounting, grounding and connection.
    d. Special tests as suggested by manufacturer, such as gap spacing and pedestal alignment shall be made where applicable.
2. Electrical tests.
    a. A dielectric absorption test shall be made on motor and starter circuit. Polarization index shall be determined for motor winding.
    b. A dielectric absorption test shall be made on motor winding. The 30/60 second ratio shall be determined.
    c. Perform insulation resistance test on pedestal per manufacturer instructions, where applicable.
    d. A rotation test shall be made to insure proper shaft direction.
    e. Measure no load and full load running current and compare to nameplate.
    f. Observe proper operation and sequence of any reduced voltage starters.
    g. Perform vibration base line test. Amplitude to be plotted vs. frequency.
    h. Perform vibration amplitude test.
    i. Check all protective devices in accordance with other sections of the Specifications.
    j. Perform overpotential test on winding to ground.
    k. The measurement shall be made with a 1000-volt megohmeter, however, the precautions noted in the tests for conductor test shall also be applied to the motors.
    l. Insulation with resistance less than 10 megohms is not acceptable.
    m. Measurements shall be recorded in a format similar to Form 26 B, contained in this section.
    n. After start-up of each motor, the current on each phase shall be measured.
        1) At no load.
        2) At defined load.
        3) Inrush current.
        4) Use Form 16B.
3. Test Values.
    a. Dielectric absorption tests shall be made in accordance with test voltage listed as specified by manufacturer. Polarization tests shall be for a 10 minute duration.

60/30 second ratio tests shall be for a 1 minute duration. Polarization index readings less than three shall be investigated. 60/30 second ratio readings less than 1.4 shall be investigated.

b. Motor measured full load current shall not exceed nameplate value.

c. Overpotential test shall be made a 80% of twice rated voltage plus 1000 volts.

d. Vibration amplitudes shall not exceed values furnished by manufacturer.

B. Low Voltage Cables - 600 Volts and Below

1. Visual and mechanical inspection.

a. Cables to be inspected for physical damage and proper connection in accordance with single line diagram.

b. Cable connection shall be torque tested to manufacturer's recommended values.

2. Electrical tests.

a. Perform insulation resistance test on each cable with respect to ground and adjacent cables.

b. Perform continuity test to insure proper cable connection.

c. Measurements shall be made prior to connection of wires to any equipment. Ends of wires are to be taped with Scotch 33+ and be physically remote from all grounded surfaces by a minimum of 2".

d. Insulation resistance measurements shall be recorded using Form 26A contained in this section.

e. Insulation with resistance of less than 10 megohms is typically not acceptable.

f. Insulation resistance test shall be performed at 1000 VDC for 1/2 minute. Insulation resistance readings shall be recorded after the one-half minute time interval has elapsed.

g. If in the opinion of the Engineer the test results are unacceptable, the Contractor will correct the installation, material or labor at no additional cost, and to the satisfaction of the Engineer.

3. Test values.

a. Insulation resistance tests shall be performed at 1000 volts D.C. for 1/2 minute.

b. Insulation tests shall be made prior to termination.

3.3 ADJUSTING

A. Subsystem Testing

1. Shall occur after the proper operation of alarm and status contacts has been demonstrated and observed by the Engineer.

2. Shall occur after the process and control devices have been adjusted as accurately as possible.

3. It is intended that the Contractor will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

4. After initial settings have been completed:

   a. Each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents.

   b. After the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control etc.

5. Subsystems, in the context discussed here, shall mean individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, blowers, etc.

3.4 DEMONSTRATION

A. Commissioning

1. Commissioning during the 7-day test as specified in "Equipment Testing and Plant Startup," shall not be attempted until all subsystems have been found to operate satisfactorily.

2. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable.

3. Simulation of process parameters shall be considered only upon receipt of a written request by the Contractor.

B. Motor current tabulation report shall reflect the values occurring during commissioning.

C. The indications of all switchboard ammeters and kilowatt meters shall be recorded every half-hour during commissioning.

END OF SECTION 260810

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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 power distribution, lighting and receptacle panelboards, complete with overcurrent devices and accessories, 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 panelboard provided.

B. Shop Drawings: Submit dimensioned drawings of panelboards including elevations of power and distribution panelboards.

C. Quality Control Submittals: Submit results of specified field tests.

PART 2 - PRODUCTS

2.1 LIGHTING AND RECEPTACLE PANELBOARDS

A. Manufacturers:

1. Panelboards rated 240V max.:
    a. Siemens Energy & Automation, Inc.: P1-P3
    b. Cutler-Hammer: Pow-R-Line 1a
    c. GE Company, GE Industrial Systems: AL
    d. Square D: NQOD

2. Panelboards rated 480/277V:
    a. Siemens Energy & Automation, Inc.: P1-P3
    b. Cutler-Hammer: Pow-R-Line 3a
    c. GE Company, GE Industrial Systems: AE
    d. Square D: NF, I Line

B. General:
1. Provide dead-front, safety-type, 60-hertz panelboards suitable for voltages, phases, and wires as indicated.
2. Comply with the applicable requirements of NEMA PB 1 and UL 50 and 67.
3. Provide minimum integrated equipment short circuit rating of 10,000 amperes RMS symmetrical at 240 volts for 240V maximum panelboards and 14,000 amperes RMS symmetrical at 277 volts for 480/277V panelboards unless otherwise indicated.

C. Enclosure:
1. Provide code gage, galvanized sheet steel cabinet type enclosure with trim and door suitable for mounting condition indicated as specified.
2. Provide panelboard front with concealed trim clamps, door with concealed hinges and flush stainless steel lock. Key locks alike.
3. Provide corrosion resistant primer treatment and light gray baked acrylic enamel finish on interior and exterior surfaces of front and trim, and on exterior surfaces of box for surface mounted panelboards.
4. Provide a metal circuit directory frame and card with a clear plastic cover attached to the inside of the panel front door. Provide minimum 6-mm-high (1/4-inch-high) by 75-mm-long (3-inch-long) space for each pole position, including spares and spaces, on the card.
5. Front shall be door-in-door type, with piano hinges.

D. Bus System:
1. Provide copper bus with current ratings and main lugs or circuit breaker as indicated.
2. Provide fully rated bus system that extends the full height of the panelboard enclosure.
3. Provide branch circuit breaker bus connections of the distributed phase sequence type.
4. Provide full ampacity, insulated neutral bus with suitable lugs for each pole position.
    a. Where indicated, provide 200 percent ampacity for 120/208 volt panelboards with suitable lugs for incoming main feeder with double neutral.
5. Provide copper ground bus.
    a. Provide a separate isolated ground bus for panelboards indicated as isolated ground panelboards.

E. Circuit Breakers:
1. Provide circuit breakers, of size and type indicated, which comply with NEMA AB 1 and UL 489.
2. Provide bolt-on type, thermal magnetic trip, molded-case circuit breakers with common trip handle for all poles.

3. Provide UL Class A ground fault interrupter circuit breakers as indicated.
4. Provide pole positions indicated as "spare" with circuit breakers of the number of poles and trip ampacities indicated.
5. Provide pole positions indicated as "space" with bus connections ready for insertion of circuit breakers of the number of poles and ampacities indicated.

F. Panelboard Accessories: Provide accessories as indicated and specified.

1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Install and test panelboards in accordance with ANSI NECA 407.
2. Surface or flush mount panelboards as indicated on drawings.
3. Align, level and securely fasten panelboards to the building.
4. Connecting raceways shall not be used to support the panelboards.
5. Plug unused panelboard openings.
6. Install trim plumb and square.
7. Provide flush mounted panels with 3 spare 1-inch conduits stubbed and capped 12 inches above the finished ceiling or 12 inches below the bottom of structure in areas with no finished ceilings.
8. Inspect panel interior, remove foreign material and debris, and tighten all connections. Neatly arrange wiring in the gutter. Temporarily secure heavy cardboard panel to front of panelboard to protect interior from dirt or damage until permanent metal front is installed.

B. Identification:

1. Coordinate with “Electrical Identification” requirements of related Division 26 sections.
2. Provide engraved plastic laminate sign mounted at top center of panelboard and indicating the following information:
    a. Panelboard designation (e.g., "RP-1A")
    b. Voltage, phases, wires (e.g., "480Y/277V, 3Ph, 4W")
    c. Source (e.g., "Fed from PP-A")
3. Typewrite the load fed by each circuit on the panelboard directory card.
4. Provide permanent type-written label mounted inside the panelboard, identifying the nominal voltage system and color coding used for each ungrounded conductor.

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.

3. Perform the following infrared scan tests and inspections and prepare reports:

   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3.3 ADJUSTING

A. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

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 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)

2.2 TELECOMMUNICATIONS OUTLETS

A. General: Coordinate with the requirements of Division 27.

2.3 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.

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. Identification: Comply with requirements of related Division 26 sections.

END OF SECTION 262726

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