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Refer to Construction Manager's Project Manual issued by A.R. Chesson Construction for additional procurement, contracting, and general requirements

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SECTION 01 9113 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.
- B. Commissioning: Commissioning is a quality oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet defined objective and criteria. The commissioning process includes specific tasks to be conducted during the project in order to verify that design, construction, and training meets the construction/contract documents.
- C. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:
 - 1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
 - 2. Verify and document proper performance of equipment and systems.
 - 3. Verify that O&M documentation left on site is complete.
 - 4. Verify that the Owner's operating personnel are adequately trained.
- D. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.
- E. Related Sections:
 - 1. Section 01 9113.02 "Statement of Systems Commissioning"
 - 2. Section 22 0700 "Commissioning of Plumbing" for technical commissioning requirements for plumbing.
 - 3. Section 23 0800 "Commissioning of HVAC" for technical commissioning requirements for HVAC.
 - 4. Section 26 0800 "Commissioning of Electrical Systems" for technical commissioning requirements for communications systems and electrical systems.

1.2 ABBREVIATIONS

- A. The following are common abbreviations used in the Specifications and in the Commissioning Plan.

A/E-	Architect and design engineers	GC-	General contractor (prime)
CxA-	Commissioning authority	MC-	Mechanical contractor
CC	Controls contractor	OR-	Owner's Representative
CM-	Construction Manager	PC-	Prefunctional checklist
Cx-	Commissioning	PM-	Project manager (of the Owner)
Cx Plan-	Commissioning Plan document	Subs-	Subcontractors to General
EC-	Electrical contractor	TAB-	Test and balance contractor
FT-	Functional performance test		

1.3 DEFINITIONS

- A. Architect/Engineer (A/E): The prime consultant (architect) and sub-consultants who comprise the design team, generally the HVAC mechanical designer/engineer and the electrical designer/engineer.
- B. Basis of Design (BoD): A document that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.
- C. Commissioning Authority (CxA): An independent agent hired by the Owner. The CxA directs and coordinates the day-to-day commissioning activities. The CxA does not take an oversight role like a CM.
- D. Commissioning Plan (Cx Plan): A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process
- E. Deferred Functional Tests : FTs that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.
- F. Deficiency : A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent).
- G. Factory Testing: Testing of equipment on-site or at the factory by factory personnel with an Owner's representative present.
- H. Functional Performance Test (FT): Test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The commissioning authority develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. FTs are performed after prefunctional checklists and startup are complete.
- I. General Contractor (GC): The prime contractor for this project. Generally refers to all the GC's subcontractors as well. Also referred to as the Contractor, in some contexts.
- J. Manual Test: Using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").
- K. Non-Compliance: See Deficiency.
- L. Non-Conformance: See Deficiency.

- M. Over-Written Value: Writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50F to 75F to verify economizer operation). See also "Simulated Signal."
- N. Owner's Project Requirements (OPR): A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.
- O. Prefunctional Checklist (PC): A list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CxA to the Sub. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some prefunctional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). The word prefunctional refers to before functional testing. Prefunctional checklists augment and are combined with the manufacturer's start-up checklist. Even without a commissioning process, contractors typically perform some, if not many, of the prefunctional checklist items a commissioning authority will recommend. However, few contractors document in writing the execution of these checklist items. Therefore, for most equipment, the contractors execute the checklists on their own. The commissioning authority only requires that the procedures be documented in writing, and does not witness much of the prefunctional check listing, except for larger or more critical pieces of equipment.
- P. Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.
- Q. Seasonal Performance Tests: FT that are deferred until the system(s) will experience conditions closer to their design conditions.
- R. Simulated Condition: Condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).
- S. Simulated Signal: Disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.
- T. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.
- U. Startup: The initial starting or activating of dynamic equipment, including executing prefunctional checklists.
- V. Subs: The subcontractors to the GC who provide and install building components and systems.
- W. Test Procedures: The step-by-step process which must be executed to fulfill the test requirements. The test procedures are developed by the CxA.
- X. Trending: Monitoring using the building control system.
- Y. Vendor: Supplier of equipment.
- Z. Warranty Period: Warranty period for entire project, including equipment components.

1.4 DOCUMENTATION PROCEDURES

A. Summary:

1. Action & Informational Submittals will be transmitted to the Commissioning Team in electronic (PDF) format using Contractors transmittal system.
2. Construction activities such as RFIs, Punch Lists, Bulletins, Daily Logs, Field Reports, etc. will be transmitted to the Commissioning Team in electronic (PDF) format using Contractors transmittal system.

B. Procedures:

1. The Commissioning Team shall use an online web based commissioning system selected by the CxA for transmitting the following commissioning activities in electronic (PDF) format:
 - a. Construction Checklist Log
 - b. Issues/Corrective Action Log
 - c. Field Reports
 - d. Progress Photos
2. Training shall be included of the online web based commissioning system, with the Commissioning Team.

1.5 COORDINATION

- A. Commissioning Team:** The members of the commissioning team consist of the Commissioning authority (CxA), the Owner's Representative (OR), the designated representative of the owner's Construction Management firm (CM), the General Contractor (GC or Contractor), the architect and design engineers (particularly the mechanical engineer), the Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB representative, the Controls Contractor (CC), any other installing subcontractors or suppliers of equipment. If known, the Owner's building or plant operator/engineer is also a member of the commissioning team.
- B. Management:** The CxA is hired by the Owner directly. The CxA directs and coordinates the commissioning activities and the reports to the OR. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
- C. Scheduling:** The CxA will work with the CM and/or GC according to established protocols to schedule the commissioning activities. The CxA will provide sufficient notice to the CM and/or GC for scheduling commissioning activities. All commissioning activities shall be integrated into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.
- D.** The CxA will provide the initial schedule of primary commissioning events at the commissioning kick-off meeting. As construction progresses more detailed schedules are developed by the CxA. The Commissioning Plan also provides a format for detailed schedules.
- E.** The CxA will notify architect/engineer, owner's representative, and owner in writing, on delays that would prevent a certificate of occupancy from being issued based on owner's expected building turn over date, due to incomplete statement of system commissioning activities, prestart activities, and startup activities.

1.6 COMMISSIONING PROCESS

- A. Commissioning Plan: The *Commissioning Plan*, provided as part of the bid documents, is binding on the Contractor. The commissioning plan provides guidance in the execution of the commissioning process. The *Specifications* will take precedence over the *Commissioning Plan*.
- B. Commissioning Process: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.
 - 1. Commissioning during construction begins with an initial commissioning meeting conducted by the CxA where the commissioning process is reviewed with the project commissioning team members.
 - 2. Additional meetings will be required throughout construction, scheduled by the CxA, through the Owner or CM, with necessary parties attending to plan, scope, coordinate, schedule future activities and resolve issues.
 - 3. Equipment documentation is submitted to the CxA, through the Owner or CM, during normal submittals, including detailed startup procedures.
 - 4. The construction checklists are to be prepared and completed by the contractor or subcontractor before and during the startup process.
 - 5. Installation verification is executed by the CxA.
 - 6. Construction checklists, installation verification checklists, TAB and startup must be completed before functional performance testing.
 - 7. Items of non-compliance in material, installation, or setup shall be corrected at no expense to the Owner.
 - 8. The contractor ensures that the subcontractors construction checklists are executed and documented and that startup and initial checkouts are performed. The CxA verifies that the TAB, construction checklists and startups were completed according to the plans. This includes the CxA reviewing TAB reports, construction checklists and startup plans/checklists. This also includes witnessing startup of selected equipment. Any testing failure is to be corrected at no additional cost to the Owner, and a re-test is to be performed, observed, and documented.
 - 9. Draft O&M's are submitted.
 - 10. Owner training plans are submitted.
 - 11. The CxA develops and implements equipment and system functional performance test procedures. The forms and procedures are reviewed by the commissioning team.
 - 12. The functional performance tests are executed by the contractor under the direction of the CxA with the assistance of the facility staff. All results are documented by the CxA.
 - 13. The CxA concurrently with the design team and Owner reviews the O&M documentation for completeness.
 - 14. Commissioning shall be completed before substantial completion with the exception of deferred testing.
 - 15. The contractor develops procedures, reviews, coordinates, and implements the training.
 - 16. Deferred testing is conducted as specified or required.

1.7 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, the Construction Manager (CM) and representatives of the Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA. Required entities include but are not limited to the following:

1. Plumbing.
2. HVAC sheet metal.
3. HVAC piping.
4. Test and Balance.
5. DDC.
6. Electrical.
7. Communications.
8. Electronic Safety and Security.
9. Fire Alarm.

B. Members Appointed by Owner:

1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
2. Representatives of the facility user and operation and maintenance personnel.
3. The Owners Representative. (If Applicable)
4. Architect and engineering design professionals.
5. Construction Manager.

1.8 OWNER'S RESPONSIBILITIES

- A. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.
- B. Provide the BoD documentation, prepared by Architect and approved by Owner, to the CxA and Contractor for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.
- C. Attend commissioning scoping meetings and additional meetings as necessary.

1.9 OWNERS REPRESENTATIVE'S RESPONSIBILITIES (IF APPLICABLE)

- A. The Owner's Representative OR shall represent the Owner during the commissioning process as follows:
 1. Provide final approval for the completion of the commissioning work.
 2. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.
 3. Attend commissioning scoping meetings and additional meetings as necessary.

1.10 ARCHITECT/ENGINEERS (AE) RESPONSIBILITIES

- A. The AE shall participate in and perform commissioning process activities including, but not limited to, the following:
 1. Attend the commissioning team meetings as necessary.
 2. Review submittals applicable to systems and equipment being commissioned after the CxA has performed their submittal review.
 3. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted.

4. Provide any design narrative and sequence documentation requested by the CxA. The designers shall assist (along with the contractors) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
5. Assist CxA in developing final functional performance test procedures.
6. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.
7. Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.

1.11 CONSTRUCTION MANAGER'S (CM) RESPONSIBILITIES

- A. The construction manager shall participate in and perform commissioning process activities including, but not limited to the following:
 1. Facilitate the coordination of the commissioning work by the CxA, and, with the GC and CxA, ensure that commissioning activities are being scheduled into the master schedule.
 2. Attend commissioning team meetings.
 3. Perform the normal review of Contractor submittals.
 4. Furnish a copy of all construction documents, addenda, requests for information, change orders and approved submittals and shop drawings related to commissioned equipment to the CxA.
 5. Provide submittals applicable to systems and equipment being commissioned, to the CxA, prior to submitting to the A/E.
 6. Provide certified submittals that that building enclosure is complete, including but not limited to, all structural components, the air barrier and vapor barrier complete, windows and doors installed, door hardware complete, door sweeps and weather stripping complete, floor and ceilings complete.
 7. Review commissioning progress and deficiency reports.
 8. Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.

1.12 CONTRACTOR'S RESPONSIBILITIES

- A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
 2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
 3. Attend commissioning team meetings.
 4. Integrate and coordinate commissioning process activities with construction schedule.
 5. Review commissioning progress and deficiency reports.
 6. Complete paper or electronic construction checklists as Work is completed and provide to the CxA.
 7. Complete commissioning process test procedures.
 8. Coordinate the training of Owner personnel and provide the times and dates of training to the CxA.
 9. Execute seasonal or deferred functional performance testing witnessed by the CxA to facilitate the Cx process.
 10. Provide a list of final settings, setpoints, ranges, schedules, and / or trend logs required by the CxA.

11. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
12. Provide specialized lifts, for equipment to be commissioned that is installed in high ceilings.
13. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor, except for stand-alone data logging equipment that may be used by the CxA.
14. Provide all project preparation and setup tests as directed by the CxA, this may include but is not limited to temporary sealing of intentional openings, removing ceiling tile, opening access doors, opening interior doors and affixing them so they cannot close during the tests. This may include preparation of adjoining spaces. This would also include staging the building so no people will be opening doors or windows during the tests.
15. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
16. Provide access to and parking (including permits) for the CxA, on or near the construction site.
17. Review test procedures for equipment installed by factory representatives.

1.13 EQUIPMENT SUPPLIERS RESPONSIBILITIES

- A. The equipment suppliers shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
 2. Assist in equipment testing per agreements with Subs.
 3. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor, except for stand-alone data logging equipment that may be used by the CxA.
 4. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

1.14 CxA'S RESPONSIBILITIES

- A. The CxA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxA may assist with problem-solving non-conformance or deficiencies, but ultimately that responsibility resides with the general contractor and the A/E. The primary role of the CxA is to develop and coordinate the execution of a testing plan, observe and document performance—that systems are functioning in accordance with the documented design intent and in accordance with the Contract Documents. The Contractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the CxA.
 1. Develop Commissioning Plan: The Commissioning Plan provides guidance in the execution of the commissioning process.
 - a. Draft PC system readiness checklists.
 - b. Draft FT narratives.
 - c. Draft Commissioning Process Schedule.

2. Coordinates and directs the commissioning activities using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
3. Coordinate the commissioning work and, with the GC and CM, ensure that commissioning activities are being scheduled into the master schedule.
4. Coordinate all submittals to be reviewed by the CxA, applicable to systems and equipment being commissioned, with the commissioning team.
5. Review all construction documents in reference to the commissioning process and provide suggested commissioning reference inserts to be provided into construction documents.
6. Review and provide comments on all submittals applicable to systems and equipment being commissioned, prior to AE. Provide comments on missing submittal information or systems not in conformance with the Contract Documents.
7. Review all construction documents, addenda, requests for information, change orders and approved submittals and shop drawings related to commissioned equipment.
8. Facilitate a kick off meeting with the commissioning team prior to the start of submittal review, to discuss commissioning process and plan. Deliver meeting minutes to the commissioning team.
9. Facilitate **[weekly] [biweekly] [monthly] [variable] <insert frequency>** commissioning team meetings throughout construction. Deliver meeting minutes to the commissioning team.
10. Request and review additional information required to perform commissioning tasks, including contractor start-up and checkout procedures.
11. Revise the commissioning plan as necessary and deliver the commissioning plan to the commissioning team.
12. Perform **[weekly] [biweekly] [monthly] [variable] <insert frequency>** site visits, as necessary, and document system readiness installation observations (applicable to systems and equipment being commissioned), progress photos, and distribute field reports to the commissioning team.
13. Develop and update construction checklist and issues/corrective action logs throughout project and deliver to construction manager.
14. **[Witness contractors prefunctional performance tests by selected site observations or perform a 20% random check of prefunctional performance tests.]** Sign off on prefunctional performance tests accordingly.
15. **[Witness testing and balancing contractor's tests by selected site observations or perform a 10% random check of submitted measurements documented in the final testing and balancing report.]** Sign off on final testing and balancing report accordingly.
16. With necessary assistance and review from A/E, write the functional performance test procedures for equipment and control systems.
17. Analyze any functional performance trend logs and monitoring data to verify performance.
18. Coordinate, witness and approve manual functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
19. Provide the statement of systems commissioning report, signed and sealed by the **[North Carolina]** registered design professional, to the code official and facility owner. The report shall identify:
 - a. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
 - b. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions.
 - c. Climatic conditions required for performance of the deferred tests.
 - d. Results of functional performance tests.
 - e. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.
20. Deliver final CxA report to the owner. Final CxA report shall include the following:

- a. Commissioning Activities Executive Summary
- b. Prefunctional Checklists
- c. Field Observation / Inspection Reports
- d. Executed Functional Performance Tests
- e. TAB Verification Report
- f. Updated Issues/Corrective Action Log

21. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

1.15 SYSTEMS TO BE COMMISSIONED

- A. Refer to individual Divisions' commissioning sections and the following, for systems that are to be commissioned.

EQUIPMENT AND CONTROL SYSTEMS TO BE COMMISSIONED		
EQUIPMENT	CONTROL SYSTEMS	SAMPLING RATE
PLUMBING SYSTEMS		
Domestic Water Heaters		100%
HVAC AND CONTROL SYSTEMS		
HVAC Power Ventilators		100%
Air Curtains		100%
Air Terminal Units		100%
Packaged, Outdoor, Air-Handling Units		100%
Split System Air Conditioners		100%
Unit Heaters		100%
ELECTRICAL SYSTEMS		
Lighting Controls and Devices		100%
Lighting - Interior		100%
Lighting - Emergency & Exit		100%
Lighting - Exterior		100%
Power - Automatic Receptacle Control		100%

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. This includes but is not limited to two-way radios, meters, and data recorders.

- B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and shall be turned over to the Owner at Project closeout.
- C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 MEETINGS

- A. Initial Meeting: The CxA, through the Owner/CM will schedule, plan, and conduct an initial commissioning meeting. The Architect/Engineer, Contractor, and Contractor's responsible parties are required to attend.
- B. Miscellaneous Meetings. Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular Subs. The CxA will plan these meetings and will minimize unnecessary time being spent by Subs.
- C. Training: Before operation and maintenance training, the Contractor shall prepare and submit training plans for all systems to be commissioned. In addition the training plans shall also include the following:
 - 1. Review installed systems, subsystems, and equipment.
 - 2. Instructor qualifications.
 - 3. Instructional methods and procedures.
 - 4. Training module outlines and contents.
 - 5. Course materials (including operation and maintenance manuals).
 - 6. Locations and other facilities required for instruction.
 - 7. Training schedule and verify availability of educational materials, instructors, audiovisual equipment, and facilities needed to avoid delays.
 - 8. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

3.2 TESTING PREPARATION

- A. CxA to receive certified submittals from contractor that that building enclosure is complete, including but not limited to, all structural components, the air barrier and vapor barrier complete, windows and doors installed, door hardware complete, door sweeps and weather stripping complete, floor and ceilings complete.

3.3 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment to be commissioned. Some systems that are not comprised so much of actual dynamic machinery, e.g., electrical system power quality, may have very simplified PCs and startup.
- B. General. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- C. Start-up and Initial Checkout Plan. The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for prefunctional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms.
 - 1. These checklists and tests are provided by the CxA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.
 - 2. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan. The full start-up plan could consist of something as simple as:
 - a. The CxA's prefunctional checklists.
 - b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
 - c. The manufacturer's normally used field checkout sheets.
 - d. Field quality control procedures identified in each equipment and control specification section.
 - 3. The full start-up procedures and the approval form may be provided to the CM for review and approval, depending on management protocol.
- D. Execution of Prefunctional Checklists and Startup. **[The primary role of the CxA in this process is to witness prefunctional performance tests by selected site observations or perform a 20% random check of prefunctional performance tests.]**
 - 1. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
 - 2. The Subs and vendors shall execute startup and provide the CxA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.
 - 3. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.
- E. Deficiencies, Non-Conformance and Approval in Checklists and Startup.

1. The Subs shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CxA, Owner, and CM.
2. The CxA reviews the report and submits either a non-compliance report or an approval form to the Sub or CM. The CxA shall work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The CxA will involve the CM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CxA recommends approval of the execution of the checklists and startup of each system to the CM using a standard form.
3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in back charges to the Contractor.

3.4 FUNCTIONAL PERFORMANCE TESTING

- A. This sub-section applies to all commissioning functional testing for all divisions.
- B. Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
 1. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.
 2. Coordination and Scheduling: The Contractor shall provide sufficient notice, regarding their completion schedule for the construction checklists and startup of all equipment and systems to allow the functional performance testing to be scheduled. The commissioning team shall oversee, witness, and document the functional performance of all equipment and systems. The Contractor/subcontractors shall execute the test, the CxA and Owner will witness and direct the tests. Performance testing shall be conducted after the construction checklists, and startup has been satisfactorily completed. The control system shall be sufficiently tested prior to use, to verify performance of other components or systems. The air balancing and water balancing shall be completed before functional testing of air or water related equipment or systems. Testing proceeds from components to sub-systems to systems. When the proper performance of all interacting individual systems has been achieved, the interface of coordinated responses between systems shall be checked.
 3. Development of Test Procedures. Before test procedures are written, the CxA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. With necessary assistance and review from A/E, the CxA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor responsible to execute a test, shall provide assistance to the CxA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to

execution, the CxA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection.

4. The CxA shall review owner-contracted, factory testing or required owner acceptance tests which the CxA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.
5. The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.

C. Test Methods:

1. Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities.
2. Simulated Conditions: Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
3. Overwritten Values: Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.
4. Simulated Signal: Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.
5. Altering Setpoints: Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55F, when the outside air temperature is above 55F, temporarily change the lockout setpoint to be 2F above the current outside air temperature.
6. Indirect Indicators: Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during prefunctional testing.
7. Setup: Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

D. Coordination and Scheduling. The Subs shall provide sufficient notice to the CxA regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The CxA will schedule functional tests through the CM, GC and affected Subs. The CxA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

1. In general, functional testing is conducted after prefunctional testing and startup has been satisfactorily completed. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from

components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

- E. Problem Solving. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the GC, Subs and A/E.

3.5 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Documentation. The CxA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. CxA is responsible for all documentation of performance testing. The CxA's **[North Carolina]** registered design professional shall provide the signed and sealed statement of systems commissioning report, to the code official and facility owner. The report shall identify:

1. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
2. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions.
3. Climatic conditions required for performance of the deferred tests.
4. Results of functional performance tests.
5. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.

- B. Non-Conformance:

1. The CxA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CM on a standard non-compliance form.
2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form.
3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the CM.
4. As tests progress and a deficiency is identified, the CxA discusses the issue with the executing contractor.
 - a. When there is no dispute on the deficiency and the Sub accepts responsibility to correct it:
 - 1) The CxA documents the deficiency and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CxA submits the non-compliance reports to the CM for signature, if required. A copy is provided to the Sub and CxA. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.
 - 2) The owner may request the services for additional commissioning with a RFP (Request For Proposal).
 - b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1) The deficiency shall be documented on the non-compliance form with the Sub's response and a copy given to the CM and to the Sub representative assumed to be responsible.

- 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Project Manager.
 - 3) The CxA documents the resolution process.
 - 4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA reschedules the test and the test is repeated until satisfactory performance is achieved.
 5. Cost of Resolution and Retesting:
 - a. The cost for the Sub to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the GC.
 - b. For a deficiency identified, not related to any prefunctional performance test or start-up fault, the following shall apply: The owner shall request the services for additional commissioning with a RFP (Request For Proposal), and will be charged to the GC, who may choose to recover costs from the responsible contractor.
 - c. The time for the CxA, CM, and A/E to coordinate resolution and direct any retesting required because a specific prefunctional checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the GC, who may choose to recover costs from the party responsible for executing the faulty prefunctional test.
 6. The Contractor shall respond in writing to the CxA and CM at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
 7. The CxA retains the original non-conformance forms until the end of the project.
 8. Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the prime contractor.
- C. Failure Due to Manufacturer Defect: If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the CM or OR. In such case, the Contractor shall provide the Owner with the following:
1. Within one week of notification from the CM or OR, the Contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the CM or OR within two weeks of the original notice.
 2. Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
 3. The CM or OR will determine whether a replacement of all identical units or a repair is acceptable.
 4. Two examples of the proposed solution will be installed by the Contractor and the CM will be allowed to test the installations for up to one week, upon which the CM or OR will decide whether to accept the solution.
 5. Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun.

The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

- D. Acceptance: The CxA notes each satisfactorily demonstrated function on the test form. Final acceptance of the performance test by the Owner is made after review by the CxA and CM, following recommendations by the A/E.

3.6 DEFERRED TESTING

- A. Unforeseen Deferred Tests: If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the Owner. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.
- B. Seasonal Testing: During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CxA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.

3.7 WRITTEN WORK PRODUCTS

- A. The commissioning process generates a number of written work products described in various parts of the Specifications:

<u>Product</u>	<u>Developed By</u>
1. Final commissioning plan	CxA
2. Cx meeting minutes	CxA
3. Commissioning schedules	CxA with GC and CM
4. Equipment documentation submittals	Subs
5. Sequence clarifications	Subs and A/E as needed
5. Prefunctional checklists	CxA
6. Startup and initial checkout plan	Subs and CxA (compilation of existing documents)
7. Startup and initial checkout forms filled out	Subs
8. Final TAB report	TAB
9. Issues log (deficiencies)	CxA
10. Commissioning Progress Record	CxA
11. Deficiency reports	CxA
12. Functional test forms	CxA
13. Filled out functional tests	CxA
15. Commissioning record book	CxA
18. Final commissioning report	CxA
19. Statement of Systems Commissioning	CxA
19. Misc. approvals	CxA

END OF SECTION 01 9113

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APPENDIX C1

STATEMENT OF SYSTEM COMMISSIONING

Part 1: Mechanical

Project Name: _____

Project Location: _____

In my professional opinion, the HVAC systems have been installed in substantial compliance with the intent of the approved project plans and specifications based on a site observation performed and upon review of the following:

YES	NO	NOT REQUIRED	ITEMS	COMMENTS
☐	☐	☐	Testing and Balance Reports	
☐	☐	☐	Operations and Maintenance Manuals for HVAC	
☐	☐	☐	HVAC Equipment	
☐	☐	☐	HVAC Controls and Operational Sequences	

Notes: _____

List of Deferred Tests:

Name: _____

Signature: _____

Date: _____

Seal Above:

Part 2: Service Water Heating

Project Name: _____

Project Location: _____

In my professional opinion, the service water heating systems have been installed and are in substantial compliance with the intent of the approved project plans and specifications based on a site observation performed and upon review of the following:

YES	NO	NOT REQUIRED	ITEMS	COMMENTS
☐	☐	☐	Manuals for Service Water Heating	
☐	☐	☐	Service Water Heating Systems	

Notes: _____

List of Deferred Tests:

Name: _____

Signature: _____

Date: _____

Seal Above:

Part 3: Electrical

Project Name: _____

Project Location: _____

In my professional opinion, the lighting systems have been installed and are in substantial compliance with the intent of the approved project plans and specifications based on a site observation performed and upon review of the following:

YES	NO	NOT REQUIRED	ITEMS	COMMENTS
☐	☐	☐	Manuals for Lighting Systems	
☐	☐	☐	Lighting Equipment	
☐	☐	☐	Lighting Controls and Operational Sequences	

Notes: _____

List of Deferred Tests:

Name: _____

Signature: _____

Date: _____

Seal Above:

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SECTION 03 3000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete mixture.
- C. Steel Reinforcement Shop Drawings: Placing Drawings that detail fabrication, bending, and placement.
 - 1. Prepare Shop Drawings in accordance with ACI 315 and 315R and the CRSI Manual of Standard Practice and Reinforcing Bar Detailing.
 - 2. Shop Drawings should include the following at a minimum:
 - a. Number, size, length and location of concrete reinforcement. Each bar should be identified using a unique mark.
 - b. Bending diagrams.
 - c. For concrete columns: provide full elevation of column member showing elevations of intersecting floors, beams, bar splices, and size and spacing of all ties.

1.3 INFORMATIONAL SUBMITTALS

- A. Material test reports.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
 - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- B. Testing Agency Qualifications: An independent agency, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1.5 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on concrete mixtures.

1.6 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with ACI 306.1.
 - 1. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- B. Hot-Weather Placement: Comply with ACI 301.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
 - 1. ACI 301.
 - 2. ACI 117.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, plain, fabricated from as-drawn steel wire into flat sheets.
- C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice."

2.3 CONCRETE MATERIALS

- A. Cementitious Materials:
 - 1. Blended Portland Cement: ASTM C 595, Type IL.
 - 2. Fly Ash: ASTM C 618, Class F.
 - 3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
- B. Normal-Weight Aggregates: ASTM C 33/C 33M, graded.
 - 1. Maximum Coarse-Aggregate Size: 1 inch nominal.
 - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
 - 3. Combined Aggregate Gradation: Well graded from coarsest to finest with not more than 18 percent and not less than 8 percent retained on an individual sieve, except that less than 8 percent may be retained on coarsest sieve and on No. 50 sieve, and less than 8 percent may be retained on sieves finer than No. 50.
- C. Air-Entraining Admixture: ASTM C 260/C 260M.

- D. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 - 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - 2. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
- E. Water: ASTM C 94/C 94M and potable.
- F. Porosity-Reducing Admixture: Proprietary formulation that reduces concrete porosity by closing capillaries in the concrete as it cures.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Concrete Moisture Solutions, Inc.; Barrier One.
 - b. ISE Logik Industries; MVRA 900.
 - c. Specialty Products Group; Vapor Lock 20/20.

2.4 VAPOR RETARDERS

- A. Sheet Vapor Retarder: ASTM E 1745, Class A, except with maximum water-vapor permeance of 0.02 U.S. perms, minimum 15 mils thick monolithic polyolefin sheet. Include manufacturer's recommended adhesive or pressure-sensitive tape.

2.5 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.

2.6 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.
- B. Bonding Agent: ASTM C 1059/C 1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

2.7 CONCRETE MIXTURES, GENERAL

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. 20 percent fly ash or 30 percent ground blast furnace slag.
- C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- D. Admixtures: Use admixtures according to manufacturer's written instructions.

2.8 CONCRETE MIXTURES FOR BUILDING ELEMENTS

- A. Slabs-on-Grade: Normal-weight concrete.
 1. Minimum Compressive Strength: As indicated at 28 days.
 2. Maximum W/C Ratio: 0.50.
 3. Minimum Cementitious Materials Content: 470 lb/cu. yd..
 4. Slump Limit: 4 inches, plus or minus 1 inch.
 5. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

2.9 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.10 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116M, and furnish batch ticket information.
 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

- A. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- B. Chamfer exterior corners and edges of permanently exposed concrete.

3.2 EMBEDDED ITEM INSTALLATION

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

3.3 VAPOR-RETARDER INSTALLATION

- A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.
 - 1. Lap joints 6 inches and seal with manufacturer's recommended tape.

3.4 STEEL REINFORCEMENT INSTALLATION

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
 - 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

3.5 JOINTS

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:
 - 1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
 - 2. Joints shall be spaced in panels no more than 12-feet on a side, with a maximum width:length aspect ratio of 1.5:1.0.
- D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as columns, concrete piers, foundation walls, grade beams, and other locations, as indicated.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections are completed.
- B. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
 - 1. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

3.7 FINISHING FORMED SURFACES

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
 - 1. Apply to concrete surfaces not exposed to public view.
- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
 - 1. Apply to concrete surfaces exposed to public view,.
- C. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.8 FINISHING FLOORS AND SLABS

- A. General: Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch in one direction.
 - 1. Apply scratch finish to surfaces to receive mortar setting beds for bonded cementitious floor finishes.
- C. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture.
 - 1. Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.
- D. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 - 1. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
 - 2. Finish and measure surface, so gap at any point between concrete surface and an unleveled, freestanding, 10-ft.- long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/8 inch.

- E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces where ceramic or quarry tile is to be installed by either thickset or thinset method. While concrete is still plastic, slightly scarify surface with a fine broom.
 - 1. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.
- F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.
 - 1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

3.9 CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- C. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days.
 - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - 3. Curing Compound: Do not use curing compounds.

3.10 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector to perform field tests and inspections and prepare testing and inspection reports.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
 - 1. Testing agency shall be responsible for providing curing container for composite samples on Site and verifying that field-cured composite samples are cured in accordance with ASTM C31/C31M.
 - 2. Testing agency shall immediately report to Architect, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
 - 3. Testing agency shall report results of tests and inspections, in writing, to Owner, Architect, Contractor, and concrete manufacturer within 48 hours of inspections and tests.
 - a. Test reports shall include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:
 - 1) Project name.
 - 2) Name of testing agency.

- 3) Names and certification numbers of field and laboratory technicians performing inspections and testing.
 - 4) Name of concrete manufacturer.
 - 5) Date and time of inspection, sampling, and field testing.
 - 6) Date and time of concrete placement.
 - 7) Location in Work of concrete represented by samples.
 - 8) Date and time sample was obtained.
 - 9) Truck and batch ticket numbers.
 - 10) Design compressive strength at 28 days.
 - 11) Concrete mixture designation, proportions, and materials.
 - 12) Field test results.
 - 13) Information on storage and curing of samples before testing, including curing method and maximum and minimum temperatures during initial curing period.
 - 14) Type of fracture and compressive break strengths at seven days and 28 days.
- C. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.
- D. Inspections:
1. Headed bolts and studs.
 2. Verification of use of required design mixture.
 3. Concrete placement, including conveying and depositing.
 4. Curing procedures and maintenance of curing temperature.
 5. Verification of concrete strength before removal of shores and forms from beams and slabs.
 6. Batch Plant Inspections: On a random basis, as determined by Architect.
- E. Concrete Tests: Testing of composite samples of fresh concrete obtained in accordance with ASTM C 172/C 172M shall be performed in accordance with the following requirements:
1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C231/C231M pressure method, for normal-weight concrete;
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 4. Concrete Temperature: ASTM C1064/C1064M:
 - a. One test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample.

5. Unit Weight: ASTM C567/C567M fresh unit weight of structural lightweight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 6. Compression Test Specimens: ASTM C31/C31M:
 - a. Cast and laboratory cure two sets of two 6-inch by 12-inch or two sets of three 4-inch by 8-inch cylinder specimens for each composite sample.
 7. Compressive-Strength Tests: ASTM C39/C39M.
 - a. Test one laboratory-cured specimen at seven days and one set at 28 days.
 - b. A compressive-strength test shall be the average compressive strength from a set of specimens obtained from same composite sample and tested at age indicated.
 8. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 9. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength, and no compressive-strength test value falls below specified compressive strength by more than 500 psi if specified compressive strength is 5000 psi, or no compressive strength test value is less than 10 percent of specified compressive strength if specified compressive strength is greater than 5000 psi.
 10. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
 11. Additional Tests:
 - a. Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
 - b. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Architect.
 - 1) Acceptance criteria for concrete strength shall be in accordance with ACI 301 section 1.6.6.3.
 12. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 13. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- F. Special Inspections: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

END OF SECTION 03 3000

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SECTION 05 5000 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Miscellaneous framing and supports.
 - 2. Steel framing and supports for mechanical and electrical equipment.
 - 3. Steel framing and supports for applications where framing and supports are not specified in other Sections.

1.2 COORDINATION

- A. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.3 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - 3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.4 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls, floor slabs, decks, and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 METALS

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Stainless Steel Sheet, Strip, and Plate: ASTM A240/A240M or ASTM A666, Type 304.

- D. Stainless Steel Bars and Shapes: ASTM A276/A276M, Type 304.
- E. Steel Tubing: ASTM A500/A500M, cold-formed steel tubing.
- F. Steel Pipe: ASTM A53/A53M, Standard Weight (Schedule 40) unless otherwise indicated.
- G. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.
 - 1. Size of Channels: 1-5/8 by 1-5/8 inches.
 - 2. Galvanized Steel: ASTM A653/A653M, structural steel, Grade 33, with G90 coating; 0.079-inch nominal thickness.
- H. Cast Iron: Either gray iron, ASTM A48/A48M, or malleable iron, ASTM A47/A47M, unless otherwise indicated.
- I. Aluminum Plate and Sheet: ASTM B209, Alloy 6061-T6.
- J. Aluminum Extrusions: ASTM B221, Alloy 6063-T6.
- K. Aluminum-Alloy Rolled Tread Plate: ASTM B632/B632M, Alloy 6061-T6.
- L. Aluminum Castings: ASTM B26/B26M, Alloy 443.0-F.
- M. Bronze Extrusions: ASTM B455, Alloy UNS No. C38500 (extruded architectural bronze).
- N. Bronze Castings: ASTM B584, Alloy UNS No. C83600 (leaded red brass) or UNS No. C84400 (leaded semired brass).
- O. Nickel Silver Extrusions: ASTM B151/B151M, Alloy UNS No. C74500.
- P. Nickel Silver Castings: ASTM B584, Alloy UNS No. C97600 (20 percent leaded nickel bronze).

2.2 FASTENERS

- A. General: Unless otherwise indicated, provide Type 304 stainless steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
 - 1. Provide stainless steel fasteners for fastening aluminum or stainless steel.
 - 2. Provide bronze fasteners for fastening bronze.
- B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563; and, where indicated, flat washers.
- C. High-Strength Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A325, Type 3, heavy-hex steel structural bolts; ASTM A563, Grade DH3, heavy-hex carbon-steel nuts; and where indicated, flat washers.
- D. Stainless Steel Bolts and Nuts: Regular hexagon-head annealed stainless steel bolts, ASTM F593; with hex nuts, ASTM F594; and, where indicated, flat washers; Alloy Group 1.

- E. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563; and, where indicated, flat washers.
 - 1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.
- F. Anchors, General: Capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing in accordance with ASTM E488/E488M, conducted by a qualified independent testing agency.
- G. Cast-in-Place Anchors in Concrete: Either threaded or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A47/A47M malleable iron or ASTM A27/A27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F2329/F2329M.
- H. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
 - 1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.
 - 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 stainless steel bolts, ASTM F593, and nuts, ASTM F594.
- I. Slotted-Channel Inserts: Cold-formed, hot-dip galvanized-steel box channels (struts) complying with MFMA-4, 1-5/8 by 7/8 inches by length indicated with anchor straps or studs not less than 3 inches long at not more than 8 inches o.c. Provide with temporary filler and tee-head bolts, complete with washers and nuts, all zinc-plated to comply with ASTM B633, Class Fe/Zn 5, as needed for fastening to inserts.

2.3 MISCELLANEOUS MATERIALS

- A. Shop Primers: Provide primers that comply with Section 09 9113 "Exterior Painting." and Section 09 9123 "Interior Painting."
- B. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
- C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- E. Shrinkage-Resistant Grout: Factory-packaged, nonmetallic, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- F. Concrete: Comply with requirements in Section 03 3000 "Cast-in-Place Concrete" for normal-weight, air-entrained concrete with a minimum 28-day compressive strength of 3000 psi.
- G. Thermoplastic Sleeves: For pipe bollard covers, see drawings for requirements.

2.4 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- J. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches, with a minimum 6-inch embedment and 2-inch hook, not less than 8 inches from ends and corners of units and 24 inches o.c., unless otherwise indicated.

2.5 MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.
- B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.
 - 1. Fabricate units from slotted channel framing where indicated.

2. Furnish inserts for units installed after concrete is placed.
- C. Galvanize miscellaneous framing and supports where indicated.
- D. Prime miscellaneous framing and supports with zinc-rich primer where indicated.

2.6 METAL LADERS

A. General:

1. Comply with ANSI A14.3[, except for elevator pit ladders].
2. For elevator pit ladders, comply with ASME A17.1/CSA B44.

B. Steel Ladders:

1. Space siderails **18 inches** apart unless otherwise indicated.
2. Siderails: Continuous, 1/2-by-2-1/2-inch steel flat bars, with eased edges.
3. Rungs: 3/4-inch- diameter, steel bars.
4. Fit rungs in centerline of siderails; plug-weld and grind smooth on outer rail faces.
5. Provide nonslip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.
6. Nonslip Surfaces for Steel Ladders: Provide nonslip surfaces on top of each rung by coating with abrasive material metallically bonded to rung.
7. Source Limitations: Obtain nonslip surfaces from single source from single manufacturer.
8. Provide platforms as indicated fabricated from welded or pressure-locked steel bar grating, supported by steel angles. Limit openings in gratings to no more than 3/4 inch in least dimension.
9. Support each ladder **at top and bottom and not more than 60 inches o.c.** with welded or bolted steel brackets.
10. Galvanize **exterior** ladders, including brackets.

2.7 METAL BOLLARDS

- A. Fabricate metal bollards from Schedule 40 steel pipe.
- B. Galvanize bollards after fabrication.
- C. Fabricate bollards for embedment in concrete footings.
- D. Thermoplastic Sleeves: For pipe bollard covers, see drawings for requirements.

2.8 GENERAL FINISH REQUIREMENTS

- A. Finish metal fabrications after assembly.
- B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.9 STEEL AND IRON FINISHES

- A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
 - 1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
- B. Preparation for Shop Priming Galvanized Items: After galvanizing, thoroughly clean galvanized surfaces of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.
- C. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
 - 1. Shop prime with primers specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting" unless indicated otherwise.
- D. Preparation for Shop Priming: Prepare surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
- E. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
 - 1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

2.10 STAINLESS STEEL FINISHES

- A. Remove tool and die marks and stretch lines or blend into finish.
 - 1. Bright, Directional Satin Finish: No. 4.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- C. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- F. Corrosion Protection: Coat concealed surfaces of aluminum that come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
1. Cast Aluminum: Heavy coat of bituminous paint.
 2. Extruded Aluminum: Two coats of clear lacquer.

3.2 INSTALLATION OF MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

3.3 INSTALLATION OF METAL LADDERS

- A. Secure ladders to adjacent construction with the clip angles attached to the stringer.
- B. Install brackets as required for securing of ladders welded or bolted to structural steel or built into masonry or concrete.

3.4 INSTALLATION OF METAL BOLLARDS

- A. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.
1. Do not fill removable bollards with concrete.
- B. Anchor bollards in place with concrete footings. Center and align bollards in holes 3 inches above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.
- C. Fill bollards solidly with concrete, mounding top surface or provide precast top to shed water.
- D. Install specified thermoplastic sleeves over metal bollards in accordance with manufacturer's printed instructions.

3.5 REPAIRS

- A. Touchup Painting:

1. Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.
 2. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 09 9113 "Exterior Painting." and Section 09 9123 "Interior Painting."
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION 05 5000

SECTION 22 0000 – SUPPLEMENTARY PLUMBING INFORMATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This form, completely filled in, shall be submitted to the engineer for approval **within 24 hours** after time of bidding.
- B. Place and "X" in the space provided, indicating the manufacturer on which the Bidder's bid price is based. In the blank space (labeled "Other") provided under each type of equipment, insert only manufacturer's names who have been approved by the engineer and the owner by written addendum. In the blank space (labeled "Breakout") provided next to each manufacture, provide a breakout cost for each manufacture for review by owner. Where no "other" is permitted as an entry, no substitutions will be considered unless approved by the engineer and owner **prior** to the project being released for bidding.
- C. Insert the name of the sub-contractor and/or supplier for the various systems or equipment as required.
- D. The following is the list of supplementary mechanical information reference in the bid submitted by:

Bidder: _____

To: _____

Dated: _____

PART 2 - PRODUCTS

2.1 Thermometer and Gauges for Plumbing

- A. Ashcroft _____
- B. Blue Ribbon Corp _____
- C. Marsh Bellofram _____
- D. Miljoco Corp. _____
- E. Terice, H.O. _____
- F. Weiss Instruments _____
- G. Weskler Instruments _____
- H. Other: _____

2.2 General Duty Valves for Plumbing

- A. Apollo Valves ____
- B. Crane ____
- C. Hammond Valve ____
- D. Jomar ____
- E. Milwaukee Valve ____
- F. Nibco-Inc. ____
- G. Powell ____
- H. Watts Industries Inc. ____
- I. Other: _____

2.3 Plumbing Insulation

- A. Johns Manville ____
- B. Knauf Insulation ____
- C. Manson Insulation ____
- D. Owens-Corning ____
- E. Other: _____

2.4 Domestic Water Piping Pressure-Seal Fittings

- A. Viega ____
- B. Nibco Press ____
- C. Apollo "Xpress" ____
- D. Other: _____

2.5 Domestic Water Piping Specialties

- A. Acorn Controls ____
- B. Ames Co. ____
- C. Apollo Valves ____

- D. Armstrong Pumps, Inc. ____
- E. Bell & Gossett ____
- F. Cash Acme ____
- G. Conbraco Inc. ____
- H. FEBCO SPX Valves ____
- I. Flow Design, Inc. ____
- J. Griswold Controls ____
- K. Honeywell ____
- L. Josam Co. ____
- M. Lawler Inc. ____
- N. Leonard Valves ____
- O. MIFAB Inc. ____
- P. Mueller ____
- Q. Nexus Valve, Inc. ____
- R. Powers ____
- S. Smith, Jay R. ____
- T. Tour & Andersson, Victaulic Company ____
- U. Tyler Pipe; Wade Div. ____
- V. Watts Industries Inc. ____
- W. Wilkins ____
- X. Woodford ____
- Y. Zurn Plumbing ____
- Z. Other: _____

2.6 Domestic Water Pumps

- A. Armstrong Pumps, Inc. ____ Breakout Cost: _____
- B. Bell & Gossett ____ Breakout Cost: _____

C.	Grundfos Pumps Corporation ____	Breakout Cost: _____
D.	WILO ____	Breakout Cost: _____
E.	Other: _____	Breakout Cost: _____

2.7 Sanitary Waste Piping Specialties

- A. Josam Co. ____
- B. MIFAB Inc. ____
- C. Smith, Jay R. ____
- D. Josam Company ____
- E. Tyler Pipe; Wade Div. ____
- F. Wade ____
- G. Watts Industries Inc. ____
- H. Zurn Plumbing ____
- I. Other: _____

2.8 Storm Drainage Piping Specialties

- A. Josam Co. ____
- B. MIFAB Inc. ____
- C. Smith, Jay R. ____
- D. Sioux Chief Mfg. Co. ____
- E. Tyler Pipe; Wade Div. ____
- F. Wade ____
- G. Watts Industries Inc. ____
- H. Zurn Plumbing ____
- I. Other: _____

2.9 Domestic Water Heaters

A.	Bradford White ____	Breakout Cost: _____

- B. Lochinvar ____ Breakout Cost: _____
- C. Ruud ____ Breakout Cost: _____
- D. Smith, A.O. ____ Breakout Cost: _____
- E. Other: _____ Breakout Cost: _____

2.10 Domestic Hot Water Expansion Tanks

- A. Amtrol Inc. ____
- B. Armstrong Pumps, Inc. ____
- C. Bell & Gossett ____
- D. Smith, A.O. ____
- E. Wessels Co. ____
- F. Other: _____

2.11 Plumbing Fixtures - Lavatories

- A. American Standard ____
- B. Kohler ____
- C. Sloan ____
- D. Mansfield ____
- E. Other: _____

2.12 Plumbing Fixtures – Water Closets

- A. American Standard ____
- B. Kohler ____
- C. Sloan ____
- D. Mansfield ____
- E. Other: _____

2.13 Plumbing Fixtures – Urinals

- A. American Standard ____
- B. Kohler ____
- C. Sloan ____
- D. Mansfield ____
- E. Other: _____

2.14 Plumbing Fixtures – Mop Basins

- A. Fiat ____
- B. Florestone ____
- C. Mustee ____
- D. ProFlo ____
- E. Swan ____
- F. Zurn ____
- G. Other: _____

2.15 Plumbing Fixtures – Faucets

- A. American Standard ____
- B. Chicago Faucet ____
- C. Delta ____
- D. Elkay ____
- E. Kohler ____
- F. Moen ____
- G. T&S Brass ____
- H. Sloan ____
- I. Speakman ____
- J. Symmons ____

K. Zurn ____

L. Other: _____

2.16 Plumbing Fixtures – Flush Valves

A. Sloan ____

B. Zurn ____

C. Other: _____

2.17 Plumbing Fixtures – Water Coolers/Bottle Fillers

A. Elkay ____

B. Oasis ____

C. Halsey-Taylor ____

D. Haws ____

E. Murdock ____

PART 3 - EXECUTION

3.1 Sub-Contractor / Supplier

A. Insulation _____

3.2 Plumbing Contractor: _____

A. Authorized Signature: _____

B. Date: _____

3.3 Shop drawings and operating instructions will be required on each applicable item of equipment. It is to the Contractor's advantage to submit these for approval as soon as possible after the Contract is awarded.

END OF SECTION 22 0000

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SECTION 22 0500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Sleeve-seal systems.
4. Sleeves.
5. Stack-sleeve fittings.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

1.2 QUALITY ASSURANCE

- A. Provide plumbing systems, equipment, and materials in accordance with North Carolina Plumbing Code and other applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. 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.
- D. Pipe Sizes: Where pipe sizes indicated on drawings are unavailable, installing contractor must provide next available pipe size up.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.
- C. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

1.4 COORDINATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of plumbing systems. For clarity of intent and for reasons of software limitations, graphic representations of systems or portions of systems may deviate from their intended or actual construction. Drawings are not fabrication drawings and are diagrammatic to indicate the general extent of work. Coordinate with all other trades to meet installation requirements specified in Division 22 sections. Include all necessary components, offsets, and fittings which are required due to the work of other trades, space constraints, or other field conditions.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- C. Coordinate installation of required supporting devices and sleeves in structural components.
- D. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Refer to architectural documents for "Access Door and Frame" requirements.
- E. Dead load placement and attachment method of hangers and pipe supports for plumbing equipment, piping, and other associated devices shall be coordinated with respective contractors of supporting structural members (Through the CM / GC). Plumbing loads shall be supported from structural members that are designed for additional equipment loads. Locate all hangers from joists or beams in accordance with structural details (See structural drawings). This may require reinforcing of joists for hanger loads not located at joist panel points and must be provided per structural details and included in the scope of the subcontractor responsible for the system being hung.
- F. Hanging devices, supports, anchors, or similar attachments shall not be supported directly from metal decks unless approved by the structural engineer of record.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

2.2 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- C. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAgl, silver alloy for refrigerant piping, unless otherwise indicated.
- D. Solvent Cements for Joining Plastic Piping:
 - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 DIELECTRIC FITTINGS

- A. Dielectric Connections: Ground joint, copper unions, ASME B16.18, cast-copper-alloy body, hexagonal stock, with ball-and-socket joint, metal-to-metal seating surfaces, and solder-joint, threaded, or solder-joint and threaded ends; and suitable system fluid, pressure and temperature.

2.4 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Plastic.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.5 SLEEVES

- A. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.6 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.7 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.

- F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

2.8 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.
 - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.

3.2 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
 - 1. Escutcheons for New Piping:
 - a. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

3.3 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Refer to architectural documents for "Joint Sealant" requirements.
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to architectural documents for "Penetration Firestopping" requirements.

3.4 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Refer to architectural documents for "Sheet Metal Flashing and Trim" requirements.
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.

4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to architectural documents for "Penetration Firestopping" requirements.

3.5 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 2. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 3. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6: Stack-sleeve fittings.
 4. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.

3.7 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.8 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Wet Piping Systems: Install dielectric unions, dielectric coupling, or dielectric nipple fittings to connect piping materials of dissimilar metals.

3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of plumbing equipment.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.

- H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.10 PAINTING

- A. of plumbing systems, equipment, and components."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.11 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 section for cast-in-place concrete."

3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.13 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
 - 1. Clean surfaces that will come into contact with grout.
 - 2. Provide forms as required for placement of grout.
 - 3. Avoid air entrapment during placement of grout.
 - 4. Place grout, completely filling equipment bases.
 - 5. Place grout on concrete bases and provide smooth bearing surface for equipment.
 - 6. Place grout around anchors.
 - 7. Cure placed grout.

3.14 PLUMBING ROOF PENETRATIONS

- A. Install plumbing roof penetrations in accordance with roof curb manufacturer's recommendations and in strict compliance with roofing manufacturer's requirements.
 - 1. Roofs with Warranty: Roof penetrations and curbs shall be installed in such a manner to maintain roofing warranty.
- B. Pipe Curbs for Pipe Penetrations: Secure boot to curb base and secure boot to pipe with adjustable stainless steel clamps.

3.15 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors. Access doors required in rated walls and ceiling shall bear the same rating. Refer to architectural documents for "Access Door and Frame" requirements.
 - 1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
 - 2. Adjust hardware and panels after installation for proper operation.

END OF SECTION 22 0500

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SECTION 22 0513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements for single-phase general-purpose motors for use on ac power systems and installed at equipment manufacturer's factory.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
 2. Split phase.
 3. Capacitor start, inductor run.
 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.4 ELECTRONIC COMMUTATION MOTOR (ECM)

- A. Description: Motor to be an electronic commutation motor (ECM) specifically designed for direct drive applications. Motors shall be permanently lubricated with heavy-duty ball bearings to match the equipment load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 22 0513

SECTION 22 0519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Thermometers.
 - 2. Gages.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 2. Comply with NSF 372, "Drinking Water System Components – Lead Content"

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Inc.
 - 2. Blue Ribbon Corp.
 - 3. Marsh Bellofram.
 - 4. Miljoco Corporation.
 - 5. Terice, H. O. Co.
 - 6. Weiss Instruments, Inc.
 - 7. Weksler Glass Thermometer Corp.
- B. Case: Metal or plastic, 9 inches long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass or plastic.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.
- C. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Inc.
 - 2. Blue Ribbon Corp.
 - 3. Marsh Bellofram.
 - 4. Miljoco Corporation.
 - 5. Terice, H. O. Co.
 - 6. Weiss Instruments, Inc.
 - 7. Weksler Glass Thermometer Corp.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
 - 1. Standard: ASME B40.100.
 - 2. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch diameter.
 - 3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 4. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
 - 5. Movement: Mechanical, with link to pressure element and connection to pointer with front recalibration.
 - 6. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - 7. Pointer: Red or other dark-color metal.
 - 8. Window: Glass or plastic.
 - 9. Ring: Metal.
 - 10. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
 - 11. Range for Fluids under Pressure: Two times operating pressure.
- C. Pressure-Gage Fittings:

1. Snubbers: ASME B40.100, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc.
2. Tubing: NPS 1/4(DN 8) copper.
3. Valves: Brass ball, with NPS 1/4.

PART 3 - EXECUTION

3.1 INSTALLATIONS

- A. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- B. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- D. Install ball valve and snubber fitting in piping for each pressure gage for fluids.
- E. Install thermometers in the following locations:
 1. Inlet and outlet of each water heater.
 2. Elsewhere as indicated on drawings.
- F. Install pressure gages in the following locations:
 1. Building water service entrance into building.
 2. Suction and discharge of each domestic water pump.
 3. Elsewhere as indicated on drawings.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

- A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.
- B. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F.

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3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 160 psi.
- B. Scale Range for Domestic Water Piping: 0 to 160 psi.

END OF SECTION 22 0519

SECTION 22 0523 – GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Copper-alloy, ball valves.
 - 2. Copper-alloy, swing check valves.
- B. Related Sections:
 - 1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
 - 2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

1.3 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded end valves.
 - 2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 3. ASME B31.9 for building services piping valves.
- C. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 2. Comply with NSF 372, "Drinking Water System Components – Lead Content"

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect valve ends from damage.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
 - 4. 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.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to Part 3 valve schedule articles for applications of valves.
- B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Bypass and Drain Connections: MSS SP-45.
- G. Valve Actuator Types:
 1. Handlever: For quarter-turn valves NPS 6 and smaller.
- H. Valves in Insulated Piping: Valves in domestic cold water lines with more than 1/2-inch insulation shall have stem extensions or extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

2.2 COPPER-ALLOY, BALL VALVES

- A. Threaded, Two-Piece, Copper-Alloy Ball Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Hammond Valve.
 - d. Jomar International, LTD.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Powell Valves.
 - h. WATTS.
 2. Description:
 - a. Standard: MSS SP-110 or MSS-145.
 - b. Two-piece body with full-port, chrome-plated bronze ball; PTFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

2.3 COPPER-ALLOY, SWING CHECK VALVES

A. Threaded, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves.
 - b. Crane.
 - c. Hammond Valve.
 - d. Jomar International, LTD.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Powell Valves.
 - h. WATTS.
2. Description:
 - a. Standard: MSS SP-139.
 - b. Class 125, Bronze ASTM B 62 body with bronze disc and bronze seat, minimum 200 psig CWP rating.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Check Valves: Install check valves for proper direction of flow.
 1. Swing Check Valves: In horizontal position with hinge pin level.

- F. Install valve tags. Comply with requirements in Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Domestic Water: For domestic water piping systems, use the following types of valves:
 - 1. Shutoff Service:
 - a. NPS 2(DN 50) and Smaller: Copper-alloy, ball valves.
 - 2. Throttling Service:
 - a. NPS 2(DN 50) and Smaller: Copper-alloy, ball valves.
 - 3. Check Valves:
 - a. NPS 2(DN 50) and Smaller: Copper-alloy, swing check valves.

END OF SECTION 22 0523

SECTION 22 0529 - 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, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Metal pipe hangers and supports.
 - 2. Metal framing systems.
 - 3. Thermal-hanger shield inserts.
 - 4. Fastener systems.
 - 5. Pipe stands.
 - 6. Equipment supports.
- B. Related Requirements:
 - 1. Section 05 5000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.

3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with intumed lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4.
3. Channels: Continuous slotted steel channel with intumed lips.
4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.3 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig or ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- C. For Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Indoor Applications: Zinc-coated steel.
 - 2. Outdoor Applications: Stainless steel.

2.5 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof or concrete slab-mounted piping.
- B. Compact Pipe Stand:
 - 1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof or concrete slab installation without membrane penetration.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 3. Hardware: Galvanized steel or polycarbonate.
 - 4. Accessories: Protection pads.

2.6 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.7 MATERIALS

- A. Carbon Steel: ASTM A 1011/A 1011M.
- B. Structural Steel: ASTM A 36/A 36M carbon-steel plates, shapes, and bars; black and galvanized.
- C. Stainless Steel: ASTM A 240/A 240M.
- D. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Refer to architectural documents for "Penetration Firestopping" requirements for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B. 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.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Fastener System Installation:
 - 1. Install powder-actuated fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- E. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof or concrete slab surface. Do not penetrate roof membrane.
- F. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.

- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, and at changes in direction of piping.
- L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- N. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - 5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- B. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches maximum.

3.6 PAINTING

- A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use thermal-hanger shield inserts for insulated piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
 4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 6. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 7. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 8. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
- I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 4. C-Clamps (MSS Type 23): For structural shapes.
 5. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 6. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 7. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

- L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
 - 1. Use powder-actuated fasteners only in concrete construction that is suitable for their installation.
- O. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 0529

SECTION 22 0553 - 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, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.

1.3 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: Black.
 - 3. Background Color: White.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 5. 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.
 - 6. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- B. Label Content: Include equipment's Drawing designation or unique equipment number.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White .
- C. Background Color: Black .
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. 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.
- F. Fasteners: Stainless-steel rivets.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME Z535.1 and ASME A13.1.
- B. Self-Adhesive Pipe Labels: Printed plastic label with contact-type, permanent-adhesive backing. Include flow arrow label with contact-type, permanent-adhesive backing.
- C. Pipe Label Contents: Include identification of piping service matching designations or abbreviations as used on Drawings.

2.4 STENCILS

- A. Stencils: Prepared with minimum letter height minimum letter height of 1 inch for equipment labels.
 - 1. Stencil Material: Fiberboard or metal.
 - 2. Stencil Paint: Exterior, gloss, black enamel unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior enamel in colors according to ASME A13.1 unless otherwise indicated.

2.5 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

2.6 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 1. Size: 3 by 5-1/4 inches minimum.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Color: Yellow background with black lettering.

2.7 CEILING MARKERS

- A. Self-Adhesive Ceiling Markers: Printed with contact-type, permanent-adhesive backing.
 1. Background Color: White.
 2. Letter Color: Black.
 3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 120 inches 1/2 inch for viewing distances greater than 120 inches.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

- C. Stenciled Equipment Label Option: Stenciled labels may be provided for outdoor equipment, equipment located within mechanical rooms, and equipment installed above ceilings, instead of manufactured equipment labels, at Installer's option.

3.4 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is concealed above ceilings or exposed in unfinished mechanical rooms; accessible maintenance spaces such as shafts, tunnels, and plenums as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
- B. Locate pipe labels where piping is exposed in finished spaces as follows:
 - 1. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 1-1/2 inches, round.
 - b. Hot Water: 1-1/2 inches, round.
 - 2. Valve-Tag Color:
 - a. Potable and Other Water: White letters on safety-green background.

3.6 CEILING MARKER INSTALLATION

- A. Install ceiling markers on t-bar ceiling grids and ceiling access panels to indicate locations of equipment, shut-off and balancing valves in main hot and cold piping lines and at branches.

3.7 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

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END OF SECTION 22 0553

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SECTION 22 0700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section includes insulation materials for plumbing systems:
- B. Related Sections:
 - 1. Division 23 Section "HVAC Insulation."

1.3 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application.
 - 1. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- D. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville.
 - b. Knauf Insulation.
 - c. Manson Insulation Inc.
 - d. Owens Corning.
 - 2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
- B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM 96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Color: White.

2.5 SEALANTS

A. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Fitting Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Adhesive: As recommended by jacket material manufacturer.
 - 2. Color: White.
 - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, unions, reducers, end caps, soil-pipe hubs, traps, and mechanical joints.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 11.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive.
 - 1. Width: 2 inches.
 - 2. Thickness: 6 mils.
 - 3. Adhesion: 64 ounces force/inch in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch in width.

2.9 SECUREMENTS

- A. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- B. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation at roof structure and seal with joint sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations:
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
- E. Refer to architectural documents for "Penetration Firestopping" requirements for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Refer to architectural documents for "Penetration Firestopping" requirements.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, and Unions:

1. Install insulation over fittings, valves, strainers, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For mineral fiber insulation, install fitted PVC cover over elbows, tees, strainers, valves, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment.

Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC fitting jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
2. Fill inside of fitting jackets to prevent collapse of jacket.

3.8 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable pipe insulation materials and thicknesses are identified for each piping system and pipe size range.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Chrome-plated pipes and fittings.

2. Underground piping.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
2. NPS 1-1/4 and Larger: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1 and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
2. NPS 1-1/4 and Larger: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.

C. Storm Water:

1. All Pipe Sizes: Vertical line up to drain body and runs within 30 Feet of drain body insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

E. Condensate and Equipment Drain Water below 60 Deg F(16 Deg C):

1. All Pipe Sizes Exposed in Mechanical Rooms and Concealed Locations: Insulation shall be one of the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch(25 mm) thick.
2. All Pipe Sizes Exposed in Finished Spaces: Insulation shall be following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch(25 mm) thick.

F. Floor Drains, Traps, and Sanitary Drain Piping within 20 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

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- B. Pipe Fittings with Mineral Fiber Insulation:
 - 1. PVC Fitting Covers: 20 mils thick, white.
- C. Exposed Vertical Piping within 8 feet of Floor:
 - 1. PVC: 30 mils thick, white.

END OF SECTION 22 0700

SECTION 22 1116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes domestic water piping inside the building.
- B. Related Sections include the following:
 - 1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and fittings.
 - 2. Division 22 Section "Domestic Water Piping Specialties" for water distribution piping specialties.

1.3 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with 160 psig, unless otherwise indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Water Samples: Specified in Part 3 "Cleaning" Article.
- B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.
- C. Comply with NSF 372, "Drinking Water System Components – Lead Content" for potable domestic water piping and components.

1.6 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of water service.
2. Do not interrupt water service without Construction Manager's written permission.

1.7 REGULATORY REQUIREMENTS

A. Comply with the provisions of the following:

1. North Carolina Plumbing Code.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.
- C. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 COPPER TUBE AND FITTINGS

- A. Soft Copper Tube: ASTM B 88, Types K , water tube, annealed temper.
 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
- B. Hard Copper Tube: ASTM B 88, Types L , water tube, drawn temper.
 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought- copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 2. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.3 PEX TUBE AND FITTINGS

- A. PEX Distribution System: Crosslinked polyethylene (PEX), manufactured in accordance with ASTM F876 and ASTM F877.
 1. Fittings: ASTM F1960 metal cold expansion or ASTM F 1807, metal insert and crimp rings.

2.4 MECHANICAL JOINT COPPER PRESS FITTING SYSTEM

- A. At the Installer's option, mechanical joint copper press fitting system using Type L copper tubing may be used for 4 inch and smaller above ground domestic water systems in lieu of soldered or threaded connections as specified.
- B. Provide manufacturer's standard mechanical joint copper press fittings and couplings which are suitable for the temperature range and operating pressures specified for each system and have the approval of state and local codes having jurisdiction.
- C. Fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for fittings shall be EPDM.
- D. Manufacturers: Subject to compliance with requirements, provide product by one of the following:
 - 1. Ridgid/Viega "ProPress"
 - 2. NIBCO "Press"
 - 3. Apollo "Xpress"

2.5 PIPING JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys.
- B. Flux: ASTM B 813, water flushable.
- C. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Standard: ASSE 1079.
 - 2. Pressure Rating: 125 psig minimum at 180 deg F.
 - 3. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Nipples:
 - 1. Standard: IAPMO PS 66.
 - 2. Electroplated steel nipple complying with ASTM F 1545.
 - 3. Pressure Rating and Temperature: 300 psig at 225 deg F.
 - 4. End Connections: Male threaded.
 - 5. Lining: Inert and noncorrosive, propylene.

2.7 VALVES

- A. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- B. Balancing and drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."
- C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."
- D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages are specified in Division 22 Section "Meters and Gages for Plumbing Piping," and drain valves and strainers are specified in Division 22 Section "Domestic Water Piping Specialties."
 - 1. Include a backflow preventer as required by local authority having jurisdiction.
- E. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- F. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 1123 "Domestic Water Pumps."
- G. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22 0519 "Meters and Gages for Plumbing Piping."

3.2 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- C. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

- D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- E. Press Connections: Copper press fitting connections shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.

3.3 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger, support products, and installation in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch.
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 4: 10 feet with 1/2-inch rod.
- F. Install supports for vertical copper tubing every 10 feet.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

3.6 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Inspect domestic water piping as follows:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2) Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
 - 2. Test domestic water piping as follows:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
- B. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
- C. Prepare reports for tests and required corrective action.

3.8 ADJUSTING

- A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
 2. Open shutoff valves to fully open position.
 3. Open throttling valves to proper setting.
 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
 5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 7. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.9 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.

3.10 PIPE AND FITTING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
- B. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 2 and Smaller: Use any of the following piping materials for each size range:
1. Soft copper tube, Type K; copper pressure fittings; and soldered joints.
 2. PEX Tube, fittings for PEX tube; and crimped joints.

- C. Aboveground Domestic Water Piping: Use any of the following piping materials for each size range:
 - 1. NPS 1 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 2. NPS 1-1/4 and NPS 1-1/2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 3. NPS 2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
- D. At Installer's option for aboveground domestic water piping, install Type L, drawn copper tube with mechanical joint copper press fittings for pipe sizes 4 inches and smaller.
 - 1. Valves with bodies meeting requirements of Section "General Duty valves for Plumbing Piping" may be used in mechanical joint copper press systems

3.11 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use bronze ball valves for piping NPS 2 and smaller.
 - 2. Throttling Duty: Use bronze ball valves for piping NPS 2 and smaller.
 - 3. Hot-Water-Piping, Balancing Duty: Calibrated balancing valves.
 - 4. Drain Duty: Hose-end drain valves.
- B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, on each water supply to plumbing fixtures that do not have supply stops and on each water supply to plumbing fixtures that do have supply stops but where take off from main or branch is not in the same room.
- C. Use check valves to maintain correct direction of domestic water flow to and from equipment.
- D. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
 - 1. Install hose-end drain valves at low points in water mains, risers, and branches.
- E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Division 22 Section "Domestic Water Piping Specialties."

END OF SECTION 22 1116

SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following domestic water piping specialties:
 - 1. Backflow preventers.
 - 2. Calibrated balancing valves.
 - 3. Temperature-actuated water mixing valves.
 - 4. Strainers.
 - 5. Wall hydrants.
 - 6. Drain valves.
 - 7. Water hammer arresters.
- B. Related Sections include the following:
 - 1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers and pressure gages in domestic water piping.
 - 2. Division 22 Section "Sanitary Waste Piping Specialties" for trap seal protection device.

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.
- B. Backflow preventer assembly test reports.

1.6 QUALITY ASSURANCE

- A. NSF Compliance as required by authorities having jurisdiction:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 and NSF 14.
- B. Comply with NSF 372 for low lead.

2.2 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Principle Backflow Preventers:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. FEBCO; SPX Valves & Controls.
 - d. Watts Industries, Inc.; Water Products Div.
 - e. Zurn Plumbing Products Group; Wilkins Div.
 2. Standard: ASSE 1013.
 3. Operation: Continuous-pressure applications.
 4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
 5. Body: Bronze for NPS 2 and smaller.
 6. End Connections: Threaded for NPS 2 and smaller.
 7. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.3 CALIBRATED BALANCING VALVES

- A. Copper-Alloy Calibrated Balancing Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett.
 - b. Flow Design Inc.
 - c. Griswold Controls.
 - d. Nexus.
 - e. Armstrong International, Inc.
 - f. Tour Andersson.
 - g. Apollo Valves.
 - h. Watts Industries, Inc.; Water Products Div.
 2. Type: Ball valve with two readout ports and memory setting indicator.

3. Body: Bronze.
4. Size: Same as connected piping, but not larger than NPS 2.

2.4 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Controls.
 - b. Cash Acme.
 - c. Apollo/Conbraco Industries, Inc.
 - d. Honeywell Water Controls.
 - e. Lawler Manufacturing Company, Inc.
 - f. Leonard Valve Company.
 - g. Powers; a Watts Industries Co.
 - h. Watts Industries, Inc.; Water Products Div.
 - i. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1070, thermostatically controlled water tempering valve.
3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
4. Body: Bronze or brass body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded with integral check valves.
7. Finish: Rough or chrome-plated bronze.
8. Tempered-Water Setting: 110 deg F.

2.5 STRAINERS FOR DOMESTIC WATER PIPING

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

1. Ames.
2. Apollo.
3. Watts.
4. Mueller
5. Wilkins.

B. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller.
3. End Connections: Threaded for NPS 2 and smaller.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch.

2.6 WALL HYDRANTS

A. Nonfreeze Wall Hydrants (NFWH):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Woodford Manufacturing Company.
 - g. Zurn Plumbing Products Group.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.

2.7 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.8 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
 - 4. Register each backflow preventer with the local jurisdiction for ongoing testing.
- C. Install calibrated balancing valves in locations where they can easily be adjusted.
- D. Install Y-pattern strainers for water on supply side of each inline pump and elsewhere as indicated.
- E. Install individual water tempering valves at each connection to lavatories and sinks in accordance with manufacturers' recommendations and in compliance with the plumbing code and authority having jurisdiction.
- F. Install water hammer arresters in water piping at locations according to PDI-WH 201.
- G. Install nonfreeze wall hydrants with valve body within building, not within outside wall.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
 - 1. Test each backflow preventer according to authorities having jurisdiction and the device's reference standard.
 - 2. Test each domestic water piping specialty according to authorities having jurisdiction and the device's reference standard.
- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

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**DOMESTIC WATER PIPING SPECIALTIES
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3.4 ADJUSTING

- A. Set field-adjustable flow set points of calibrated balancing valves.
- B. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 22 1119

SECTION 22 1123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic water circulation:
 - 1. Wet rotor inline pumps.
- B. Terminology used in this Section is from HI 1.1-1.2 and HI 5.1-5.6.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain domestic water pumps through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated.
- C. 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.
- D. UL Compliance: Comply with UL 778 for motor-operated water pumps.
- E. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 WET ROTOR INLINE PUMPS

- A. Manufacturers:
 1. Armstrong Pumps, Inc.
 2. Bell & Gossett.
 3. Grundfos Pumps Corporation.
 4. WILO (5hp and under).
- B. Description: Factory-assembled and -tested, wet rotor in-line pumps with EC motor and integrated variable speed drive.
 1. Pump and Motor Assembly: Motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
 2. Casing: Lead-free bronze, with companion-flange connections.
 3. Impeller: Plastic or stainless steel.
 4. Shaft: Stainless steel.
 5. Rotor: Permanent magnet.
 6. Bearing: Carbon sleeve.
 7. Gasket/O-Ring: EPDM.
 8. All Other Wetted Parts: Stainless steel.
 9. Motor Type: Electronically commutated motor /permanent magnet and includes:
 - a. Class F motor insulation.
 - b. Integrated motor protection against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).
 10. Integrated Controls:
 - a. MODBUS or BACnet connections built into the pump as standard.

- b. Integral temperature sensor.
- c. Start/Stop dry contact relay.
- d. Analog inputs, such as 0-10V and 4-20mA inputs built into the pump.

- 11. Maximum Working Pressure: 175 psi.
- 12. Maximum Working Temperature: 230°F.

2.3 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 0500 "Common Motor Requirements for Plumbing Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.4 CONTROLS

- A. Temperature Sensor: Adjustable for control of hot-water circulation pump, provided by pump manufacturer.
 - 1. Type: Strap-on sensor for remote installation on hot-water circulation piping.
 - 2. Operation of Pump: On or off.
 - 3. Settings: Start pump at 100 deg F and stop pump at 120 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- C. Install horizontally mounted, in-line, centrifugal pumps with shaft(s) horizontal.
- D. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.

3.3 CONTROL INSTALLATION

- A. Install remote temperature sensors on hot-water return piping.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
 - 1. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- F. Connect temperature sensors to pumps that they control.

3.5 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 STARTUP SERVICE

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections with the assistance of a factory-authorized service representative and prepare test reports:
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set controls for automatic starting and stopping operation of pumps.
 - 5. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 7. Start motor.
 - 8. Open discharge valve slowly.
 - 9. Adjust temperature settings on thermostats.

3.7 ADJUSTING

- A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Coordinate with general contractor for additional demonstration and training requirements.

END OF SECTION 22 1123

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SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes soil and waste, sanitary drainage and vent piping inside the building.
- B. The following Sections contain related requirements:
 - 1. Division 22 Section "Sanitary Waste Piping Specialties" for soil, waste, and vent piping system specialties.

1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

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

1.6 REGULATORY REQUIREMENTS

- A. Comply with the provisions of the following:
 - 1. North Carolina Plumbing Code.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.
- C. Hub-and-Spigot, Cast-Iron Pipe and Fittings: ASTM A 74, Service class.
 - 1. Gaskets: ASTM C 564, rubber.
 - 2. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.
- D. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 and CISPI 301.
 - 1. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
- E. Steel Pipe: ASTM A 53/A 53M, Type E, Schedule 40, galvanized. Include ends matching joining method.
 - 1. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.
 - a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
- F. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.
 - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.
- G. Adhesive Primer: ASTM F656.
- H. Solvent Cement: ASTM D2564.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling. Refer to civil documents for "Earth Moving" requirements.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 - 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.

- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- E. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- F. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."
- G. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- H. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- I. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
 - 1. Below slab sanitary drains shall be minimum 3-inch (76-mm) unless otherwise indicated with reducer down to above slab pipe size located at floor line.
- J. Install soil and waste drainage and vent piping at the minimum slopes required by plumbing code.
- K. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- L. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- M. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.3 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
 - 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.
- C. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
 - 1. For indoor applications, use PVC glue that has a VOC content of 510 g/L or less.
 - 2. For indoor applications, use PVC primer that has a VOC content of 550 g/L or less.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 4. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
- H. Install supports for vertical steel piping every 15 feet.
- I. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
 - 2. NPS 3: 48 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
- J. Install supports for vertical PVC piping every 48 inches.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to other Division 22 plumbing fixtures sections.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
 - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 5. Comply with requirements for cleanouts and drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."

3.6 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping.
- B. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 48 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
 - a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
 - a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
 - b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
 - c. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
 - a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
 - b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
 - c. Air pressure must remain constant without introducing additional air throughout period of inspection.
 - d. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.
- E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.9 PIPING SCHEDULE

- A. Aboveground, soil, waste, and vent piping NPS 1 1/2(DN 40) and smaller shall be any of the following:
 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 2. Steel pipe, drainage fittings, and threaded joints.
- B. Aboveground, soil, waste, and vent piping NPS 1 1/2(DN 40) and smaller concealed within walls, insulated, or exposed to view shall be any of the following:

1. PVC pipe, PVC socket fittings, and solvent-cemented joints.
- C. Aboveground, soil, waste, and vent piping NPS 2(DN 50) through NPS 10(DN 250) shall be any of the following:
1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
- D. Aboveground, soil, waste, and vent piping NPS 2(DN 50) through NPS 10(DN 250) concealed within walls, insulated, or exposed to view shall be any of the following
1. PVC pipe, PVC socket fittings, and solvent-cemented joints.
- E. Underground, soil, waste, and vent piping NPS 10(DN 250) and smaller shall be any of the following:
1. Service class, hub-and-spigot, cast-iron soil pipe and fittings; gaskets; and compression joints.
 2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 3. PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION 22 1316

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SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
 - 1. Cleanouts.
 - 2. Floor drains.
 - 3. Trap-seal protection devices.
 - 4. Air-admittance valves.
 - 5. Miscellaneous drainage piping specialties.
- B. Related Requirements:
 - 1. Section 22 1423 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
 - 2. Refer to civil documents for "Stormwater Conveyance" requirements for storm drainage piping and piping specialties outside the building.

1.3 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of sanitary waste piping specialties through one source from a single manufacturer.
- B. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- C. Comply with NSF 14 for plastic sanitary waste piping specialty components.

PART 2 - PRODUCTS

2.1 CLEANOUTS

- A. Exposed End of Pipe Cast-Iron Cleanouts:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.

- e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Standard: ASME A112.36.2M.
 - 3. Size: Same as connected drainage piping
 - 4. Body Material: Hubless, cast-iron soil pipe as required to match connected piping.
 - 5. Closure: Countersunk, brass plug.
 - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
- B. Cast-Iron Floor Cleanouts:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Div.
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.36.2M for adjustable housing cleanout.
 - 3. Size: Same as connected branch.
 - 4. Type: Adjustable housing.
 - 5. Body or Ferrule: Cast iron.
 - 6. Outlet Connection: Spigot.
 - 7. Closure: Brass plug with straight threads and gasket.
 - 8. Adjustable Housing Material: Cast iron with threads.
 - 9. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
 - 10. Frame and Cover Type:
 - a. Ceramic, Mosaic & Quarry Tile Floors: Terrazzo top type with square nickel bronze top.
 - b. Asphalt & Vinyl Tile Floors: Tile top type with square nickel bronze top.
 - c. Carpet Floors: Carpet marker type with round nickel bronze top.
 - d. Other Finished Floors: Heavy duty type with round nickel bronze top.
 - e. Unfinished Concrete Floors: Heavy duty type with round cast iron top.
- C. Cast-Iron Interior Finished Wall Cleanouts:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.36.2M. Include wall access.
 - 3. Size: Same as connected drainage piping.
 - 4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 - 5. Closure: Countersunk, drilled-and-threaded brass plug.
 - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 - 7. Wall Access: Round, flat, stainless-steel cover plate with screw.
- D. Cast-Iron Interior Unfinished Accessible Area Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains - General:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Wade.
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3.

B. Cast Iron Floor Drains: Coated gray iron body having integral double drainage flange with weep holes and no-hub spigot or push-on bottom outlet. Provide flashing clamp device where located in membrane floor or when flashing is required for pans. Floor drain type designations and sizes are indicated on Drawings and scheduled below:

1. FD-1: Toilet rooms and finished areas not specifically noted, "Wade" 1100G6 or equivalent with 6 inch (150 mm) square nickel bronze adjustable top.

2.3 TRAP SEAL PROTECTION DEVICES

A. Barrier Type Trap Seal Protection Devices:

1. Subject to compliance with requirements, provide SureSeal Manufacturing Inline Floor Drain Trap Sealer, MIFAB MI-GARD Trap Seal, or Jay R. Smith Model 2692 Trap Seal.
2. Standard: ASSE 1072.
3. Size: 2 inch thru 4 inch as required

2.4 AIR-ADMITTANCE VALVES

A. Fixture Air-Admittance Valves:

1. Standard: ASSE 1051, Type A for single fixture or Type B for branch piping.
2. Housing: Plastic.
3. Operation: Mechanical sealing diaphragm.
4. Size: Same as connected fixture or branch vent piping.

PART 1 - EXECUTION

1.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 1. Install wall cleanouts in all finished spaces.
 2. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 3. Locate at each change in direction of piping greater than 45 degrees.
 4. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 5. Locate at base of each vertical soil and waste stack.
 6. Align square tops parallel with building walls.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
 5. Align square tops parallel with floor tile.
- F. Install trap-seal protection devices at floor sink and floor drain outlets (omit at shower floor drains) during trim out stage of project.
- G. Install fixture air-admittance valves on fixture drain piping.
- H. Install air-admittance-valve wall boxes recessed in wall.
- I. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- J. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

- K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- L. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

1.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

1.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 1319

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SECTION 22 1413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes storm drainage piping inside the building and to a point five feet outside the building.
- B. Related Sections include the following:
 - 1. Division 22 Section "Storm Drainage Piping Specialties" for storm drainage piping system specialties.
 - 2. Refer to civil documents for "Stormwater Conveyance" requirements for storm drainage piping and piping specialties outside the building.

1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - 1. Storm Drainage Piping: 10-foot head of water.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

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

1.6 REGULATORY REQUIREMENTS

- A. Comply with the provisions of the following:
 - 1. North Carolina Plumbing Code.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.
- B. Hub-and-Spigot, Cast-Iron Pipe and Fittings: ASTM A 74, Service class.
 - 1. Gaskets: ASTM C 564, rubber.
 - 2. Caulking Materials: ASTM B 29, pure lead and oakum or hemp fiber.
- C. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 and CISPI 301.
 - 1. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
- D. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.
 - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.
- E. Adhesive Primer: ASTM F 656.
- F. Solvent Cement: ASTM D 2564.

PART 3 - EXECUTION

3.1 EARTH MOVING

- 3.2 Refer to civil documents for "Earth Moving" requirements for excavating, trenching, and backfilling.

3.3 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 - 1. Indicated locations and arrangements were used to size pipe and other design considerations.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- E. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."
- F. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."
- G. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- H. Make changes in direction for storm piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- I. Lay buried building drain piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- J. Install storm drainage piping at the minimum slopes required by plumbing code.
- K. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- L. Install above slab PVC storm drainage piping according to ASTM D 2665.
- M. Install underground PVC storm drainage piping according to ASTM D 2321.
- N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- O. Paint interiors of PVC overflow roof drain piping for 24 inches upstream of outlet fitting. Apply one coat of flat black latex finish. Refer to architectural documents for "Exterior Painting" and "Interior Painting" requirements.

3.4 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- C. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
- D. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
 - 1. For indoor applications, use PVC glue that has a VOC content of 510 g/L or less.

2. For indoor applications, use PVC primer that has a VOC content of 550 g/L or less.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
 2. NPS 3: 48 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
- H. Install supports for vertical PVC piping every 48 inches.
- I. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.6 CONNECTIONS

- A. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- B. Connect storm drainage piping to roof drains and storm drainage specialties.

3.7 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 48 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
 - a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping being tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 4. Prepare reports for tests and required corrective action.

3.8 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.9 PIPING SCHEDULE

- A. Aboveground storm drainage piping NPS 2(DN 50) through NPS 10(DN 250) shall be any of the following:
 - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
- B. Aboveground storm drainage piping NPS 2(DN 50) through NPS 10(DN 250) concealed within walls, insulated, or exposed to view shall be any of the following:

1. PVC pipe, PVC socket fittings, and solvent-cemented joints.
- C. Underground storm drainage piping NPS 10(DN 250) and smaller shall be any of the following:
1. Service class, hub-and-spigot, cast-iron soil pipe and fittings; gaskets; and compression joints.
 2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 3. PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION 22 1413

SECTION 22 1423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following storm drainage piping specialties:
 - 1. Cleanouts.
 - 2. Roof drains.
- B. Related Requirements:
 - 1. Refer to architectural documents for "Sheet Metal Flashing and Trim" requirements for penetrations of roofs.
 - 2. Refer to architectural documents for "Penetration Firestopping" requirements for firestopping roof penetrations.

1.3 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Source Limitations: Obtain same type of storm drainage piping specialties through one source from a single manufacturer.

PART 2 - PRODUCTS

2.1 CLEANOUTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Josam Company; Josam Div.
 - 2. MIFAB, Inc.
 - 3. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - 4. Sioux Chief Mfg. Co.
 - 5. Tyler Pipe; Wade Div.
 - 6. Watts Drainage Products Inc.
 - 7. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Exposed End of Pipe Cast-Iron Cleanouts:

1. Standard: ASME A112.36.2M.
2. Size: Same as connected drainage piping
3. Body Material: Hubless, cast-iron soil pipe as required to match connected piping.
4. Closure: Countersunk, brass plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Cast-Iron Floor Cleanouts:

1. Standard: ASME A112.36.2M for adjustable housing cleanout.
2. Size: Same as connected branch.
3. Type: Adjustable housing.
4. Body or Ferrule: Cast iron.
5. Outlet Connection: Spigot.
6. Closure: Brass plug with straight threads and gasket.
7. Adjustable Housing Material: Cast iron with threads.
8. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
9. Frame and Cover Type:
 - a. Ceramic, Mosaic & Quarry Tile Floors: Terrazzo top type with square nickel bronze top.
 - b. Asphalt & Vinyl Tile Floors: Tile top type with square nickel bronze top.
 - c. Carpet Floors: Carpet marker type with round nickel bronze top.
 - d. Other Finished Floors: Heavy duty type with round nickel bronze top.
 - e. Unfinished Concrete Floors: Heavy duty type with round cast iron top.

D. Cast-Iron Interior Finished Wall Cleanouts:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk, drilled-and-threaded brass plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
6. Wall Access: Round, flat, stainless-steel cover plate with screw.

E. Cast-Iron Interior Unfinished Accessible Area Cleanouts:

1. Standard: ASME A112.36.2M.
2. Size: Same as connected drainage piping.
3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk, drilled-and-threaded brass plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 ROOF DRAINS

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

1. Josam Company; Josam Div.
2. MIFAB, Inc.
3. Sioux Chief Mfg. Co.
4. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
5. Tyler Pipe; Wade Div.
6. Wade.

7. Watts Drainage Products Inc.
 8. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Cast-Iron Roof Drains - General:
1. Standard: ASME A112.21.2M.
- C. Cast Iron Roof Drains: Coated cast iron wide flange body, flashing ring/gravel stop, standard under deck clamp and cast iron dome strainer. Provide steel bearing pan in roof decks for added bearing surface area. Roof drain type designations and sizes are indicated on drawings and scheduled below:
1. RD-1: General Roof Locations "J.R. Smith" 1010 or equivalent with cast iron dome, bearing pan, deck clamp, and extension flange.
 - a. Coordinate height of required extension flange with insulation thickness at each roof drain.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Install wall cleanouts in all finished spaces.
 2. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 3. Locate at each change in direction of piping greater than 45 degrees.
 4. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 5. Locate at base of each vertical soil and waste stack.
 6. For cleanouts at grade within 5'-0" of building install cleanouts and extension from drain pipe to cleanout at grade where indicated. Set cleanout in poured concrete block 18 inches by 18 inches by 12 inches deep, except where location is in concrete paving. Set top of cleanout 1 inch above surrounding earth grade or flush with grade when installed in paving.
 7. Align square tops parallel with building walls.
- C. For floor cleanouts for piping below floors in unfinished spaces or other spaces as indicated, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 2. Position roof drains for easy access and maintenance.

- 3. Install expansion joints in downspouts 25 feet or more in height, where horizontal offset is less than 5 feet.

F. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

G. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 1423

SECTION 22 3300 - ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following electric water heaters:

1. Commercial, storage electric water heaters.
2. Compression tanks.
3. Water heater accessories.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Wiring Diagrams: Power, signal, factory control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of electric water heaters through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated.
- C. 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.
- D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
- E. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

F. NSF Compliance as required by authorities having jurisdiction:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

1.6 COORDINATION

- A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 COMMERCIAL ELECTRIC WATER HEATERS

- A. Commercial, Storage Electric Water Heaters: Comply with UL 1453 requirements for storage-tank-type water heaters.
1. Manufacturers:
 - a. Bradford White Corporation.
 - b. Lochinvar Corporation.
 - c. Ruud Water Heater Div.; Rheem Manufacturing Company.
 - d. Smith, A. O. Water Products Company.
 2. Storage-Tank Construction: Non-ASME-code, steel vertical arrangement.
 - a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
 - 1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 - b. Pressure Rating: 150 psig.
 - c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 3. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.

- d. Insulation: Comply with ASHRAE/IESNA 90.1.
- e. Jacket: Steel with enameled finish.
- f. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
- g. Temperature Control: Adjustable thermostat.
- h. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
- i. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

2.3 COMPRESSION TANKS

- A. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
 - 1. Manufacturers:
 - a. AMTROL Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell and Gossett.
 - d. Smith, A. O.; Aqua-Air Div.
 - e. Wessels Co.
 - 2. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.

2.4 WATER HEATER ACCESSORIES

- A. Vacuum Relief Valves: ANSI Z21.22 rated and CSA certified with all brass body and protective cap.
- B. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
- C. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 3/4.
- D. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004.

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.
- C. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

- A. Install commercial water heaters on concrete bases.
 - 1. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- D. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
- E. Install thermometer on inlet and outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.
- F. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
- G. Fill water heaters with water.
- H. Charge compression tanks with air.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Arrange with the Authority having jurisdiction for inspection and certification of domestic water heater installation. Installer shall be responsible for any required fees.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, confirm proper operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial electric water heaters. Coordinate with general contractor for additional demonstration and training requirements.

END OF SECTION 22 3300

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SECTION 22 4000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes plumbing fixtures and related components.
- B. Related Sections include the following:
 - 1. Division 22 Section "Domestic Water Piping Specialties" for mixing valves and specialty fixtures not included in this Section.

1.2 DEFINITIONS

- A. Barrier-Free Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Piping and general-duty valves are included where indicated. Fittings specified in this Section include:
 - 1. Supplies and stops.
 - 2. Faucets and spouts.
 - 3. Drains and tailpieces.
 - 4. Traps and waste pipes.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- B. Regulatory Requirements: Comply with the following:

1. North Carolina Building Code (ANSI A117) for plumbing fixtures for people with disabilities.
 2. North Carolina Building Code.
 3. Local authority having jurisdiction.
- C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- D. NSF Compliance as required by authorities having jurisdiction:
1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"
- E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with specified requirements, provide commercial grade plumbing fixtures by one of the following:
1. Lavatories, Water Closets, Urinals:
 - a. American Standard
 - b. Kohler
 - c. Zurn
 - d. Sloan
 - e. Mansfield
 2. Mop Basins:
 - a. Fiat
 - b. Florestone
 - c. Mustee
 - d. ProFlo
 - e. Swan
 - f. Zurn
 3. Faucets:
 - a. American Standard
 - b. Chicago Faucet
 - c. Delta
 - d. Elkay
 - e. Kohler
 - f. Moen.
 - g. T & S Brass
 - h. Sloan
 - i. Speakman
 - j. Symmons

- k. Zurn
- 4. Flush Valves:
 - a. Sloan
 - b. Zurn
- 5. Water Closet Seats:
 - a. American Standard
 - b. Bemis
 - c. Centoco
 - d. Church
 - e. Kohler
 - f. Olsonite
 - g. ProFlo
 - h. Zurn
- 6. Water Coolers:
 - a. Elkay
 - b. Oasis
 - c. Halsey-Taylor
 - d. Haws
 - e. Murdock
- 7. Fixture Supports:
 - a. Josam
 - b. Wade
 - c. Zurn
 - d. Jay R. Smith
 - e. MIFAB
 - f. Watts.

2.2 WATER CLOSETS

- A. Water Closets: As indicated on architectural drawings. Provide carriers, toilet seat, and FV-1 flush valve as specified in the Articles below. (Refer to mounting heights schedule for Barrier-Free requirements.)

2.3 URINALS

- A. Urinals: As indicated on architectural drawings. Provide carriers and FV-2 flush valve as specified in the Articles below. (Refer to mounting heights schedule for Barrier-Free rim heights.)

2.4 LAVATORIES

- A. Lavatories: As indicated on architectural drawings. Provide F-1 faucet, trap, supplies and stops as specified in the Articles below.
 - 1. Provide offset tailpiece on barrier-free units.
 - 2. Provide thermostatic mixing valve on hot water line to barrier-free lavatory faucet. Mount below lavatory within trap cover. Refer to Section 22 1119 for mixing valve.

2.5 MOP BASINS

- A. Mop Basins: As indicated on architectural drawings. Furnish with manufacture's standard mop hanger, two stainless steel wall shields, and hose and hose bracket accessories for field installation. Provide F-2 faucet as specified in the Articles below.

2.6 ELECTRIC WATER COOLERS

- A. Electric Water Coolers (Barrier-Free): As indicated on architectural drawings. Provide P-trap and supply with stop.

2.7 FAUCETS

- A. Lavatory Faucet(s): As indicated on architectural drawings.
- B. F-2 Service Faucet(s): As indicated on architectural drawings. Rough chrome plated cast brass, combination service sink fitting with vacuum breaker, 3/4" threaded hose spout, metal lever handles indexed "HOT" and "COLD" plus red and blue index tabs, wall brace, pail hook, adjustable flanged female supply arms and having integral stops.

2.8 FLUSH VALVES

- A. FV-1 Flush Valve: As indicated on architectural drawings.
- B. FV-2 Flush Valve: As indicated on architectural drawings.

2.9 SENSOR FAUCET AND FLUSH VALVE ACCESSORIES

- A. Provide flush valve hardwired power converters, mini junction boxes, and required low voltage wiring for power connection to sensor operated flush valves.
 - 1. Include separate system for each toilet room.
- B. Provide faucet plug-in power converters and required low voltage wiring for power connection to sensor operated faucets.
 - 1. Include separate system for each toilet room.

2.10 TOILET SEATS

- A. Elongated, heavy duty, solid white plastic toilet seats with molded-in bumpers, closed back/open front, less cover, and having stainless steel check hinge and stainless steel nuts. Centoco Model 500STSCC or equivalent.
- B. Round, heavy duty, solid white plastic toilet seats with molded-in bumpers, closed back/open front, less cover, and having stainless steel check hinge. Olsonite Model 126CC or equivalent.

2.11 FIXTURE SUPPORTS

- A. General: All Fixture support carriers to conform to ANSI A112.6.1M (American National Standards Institute).
- B. Urinal and Water Cooler Support Carriers: Wade W-400-AM11-M36 or equivalent foot supported carrier with rectangular structural steel uprights, top support plate, and lower bearing plate with studs.
- C. Water Closet Support Carriers: Wade W-300 series or equivalent foot supported carrier with vertical or horizontal waste fitting configuration as required by waste piping installation. Single closet carriers shall be provided with rear anchoring foot. Closet coupling and fixture support rods shall be of proper length for wall thickness. M4 rod support feet shall be furnished when span from inside of finish block wall to face of carrier faceplate exceeds 6". M4 rod support feet shall also be provided on each water closet carrier installed on stud type wall construction.

2.12 UNDER-LAVATORY GUARDS

- A. Under-Lavatory Guard:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Plumberex Specialty Products, Inc.
 - b. Truebro by IPS Corporation.
 - c. ProFlo
 - 2. Description: Insulating pipe covering for supply and drain piping assemblies that prevent direct contact with and burns from piping; allow service access without removing coverings.
 - 3. Material and Finish: Antimicrobial, molded plastic, white.

2.13 FITTINGS, TRIM AND ACCESSORIES

- A. Fittings for Plumbing Fixtures: Fittings include the following:
 - 1. Supply Inlets: Copper tube, size required for final connection.
 - 2. Supply Stops: Chrome-plated brass body, angle or straight configuration with compression fittings, loose-key type; size to match inlet pipe and supply riser.
 - 3. Supply Risers: 3/8-inch OD flexible chrome-plated brass tube with 1/2-inch IPS straight or offset, knob-end tailpiece.
 - 4. Traps: Chrome-plated, 17 gauge tubular brass P-trap and wall bend, with slip-joint inlet, wall flange, and escutcheon; same size as fixture outlet connection.
 - a. For concealed applications within water coolers or casework, ASTM F 409 PVC one or two-piece trap and waste to wall maybe used.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

- B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
- E. Install counter-mounting fixtures in and attached to casework.
- F. Install fixtures level and plumb according to roughing-in drawings.
- G. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- J. Install toilet seats on water closets.
- K. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- L. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."
- M. Set mop basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

- N. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Refer to architectural documents for "Joint Sealant" requirements.
- O. Install hardwired sensor operated flush valves in accordance with manufacturer's instructions. Coordinate with Division 26.
 - 1. Coordinate water rough-in dimension, flush tube length, and grab bar mounting height to provide proper clearances.
- P. Install flush valves in accordance with manufacturer's instructions. Adjust settings and verify proper operation.
 - 1. Install flush valves on barrier-free units with handles on wide side of stall.
- Q. Install under-lavatory protective shield at wall mounted lavatory locations in accordance with manufacturer's installation instructions.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.5 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

- C. Adjust water pressure at drinking fountains, electric water coolers, faucets, and flush valves having controls, to produce proper flow and stream.
- D. Adjust mixing valve maximum temperature limit stop in accordance with manufacturers' recommendations and in compliance with the plumbing code and authority having jurisdiction.
- E. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

- A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 - 2. Remove sediment and debris from drains.
- B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain the following:
 - 1. Faucets.
 - 2. Flush valves.
 - 3. Water coolers
- B. Coordinate with general contractor for additional demonstration and training requirements.

3.9 FIXTURE HEIGHT SCHEDULE

- A. Install fixtures to heights above finished floor as indicated.
 - 1. Water Closet:
 - a. Standard: 15 inches to top of bowl rim.
 - b. Barrier Free: 17 to 19 inches, top of seat.
 - 2. Water Closet Flush Valves:
 - a. Standard: 11 inches min. above bowl rim.
 - 3. Urinal:

- a. Standard: 22 inches to top of bowl rim.
 - b. Barrier Free: 17 inches maximum to top of bowl rim.
4. Urinal Flush Valves:
- a. Standard: 11 inches min. above top.
 - b. Barrier Free: 46 inches maximum to flush valve handle.
5. Water Cooler:
- a. Standard Adult: Minimum 38 inches and maximum 43 inches to spout outlet.
 - b. Barrier Free: Maximum 36 inches to spout outlet.

3.10 FIXTURE ROUGH-IN SCHEDULE

- A. Line sizes indicated below are run-out sizes, reduce size as required at connection to fixture. Main lines and drops shall be installed in sizes as indicated on drawings.

- 1. Water Closet (Flush Valve Type):
 - a. Cold Water: 1-1/2 Inch.
 - b. Waste: 4 Inch.
 - c. Vent: 2 Inch.
- 2. Urinal (Flush Valve Type):
 - a. Cold Water: 1 Inch.
 - b. Waste: 2 Inch.
 - c. Vent: 1-1/2 Inch.
- 3. Lavatory:
 - a. Hot Water: 1/2 Inch.
 - b. Cold Water: 1/2 Inch.
 - c. Waste: 1-1/2 Inch.
 - d. Vent: 1-1/4 Inch.
- 4. Water Cooler:
 - a. Cold Water: 1/2 Inch.
 - b. Waste: 1-1/4 Inch.
 - c. Vent: 1-1/4 Inch.
- 5. Mop Basin:
 - a. Hot Water: 3/4 inch.
 - b. Cold Water: 3/4 inch.
 - c. Waste: 3 inch.
 - d. Vent: 1-1/2 inch.

END OF SECTION 22 4000

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SECTION 23 0000 – SUPPLEMENTARY MECHANICAL INFORMATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This form, completely filled in, shall be submitted to the engineer for approval **within 24 hours** after time of bidding.
- B. Place and “X” in the space provided, indicating the manufacturer on which the Bidder’s bid price is based. In the blank space (labeled “Other”) provided under each type of equipment, insert only manufacturer’s names who have been approved by the engineer and the owner by written addendum. In the blank space (labeled “Breakout”) provided next to each manufacture, provide a breakout cost for each manufacture for review by owner. Where no “other” is permitted as an entry, no substitutions will be considered unless approved by the engineer and owner **prior** to the project being released for bidding.
- C. Insert the name of the sub-contractor and/or supplier for the various systems or equipment as required.
- D. The following is the list of supplementary mechanical information reference in the bid submitted by:

Bidder: _____

To: _____

Dated: _____

PART 2 - PRODUCTS

2.1 Equipment Service Platforms

- A. Miro Industries, Inc. _____
- B. PHP Systems _____
- C. Rooftop Support Systems _____
- D. Other: _____

2.2 HVAC Insulation

- A. Certain-Teed _____
- B. Johns Manville _____
- C. Knauf Insulation _____
- D. Owens-Corning _____

E. Other: _____

2.3 Liquefied-Petroleum Gas Shut Off Valves

A. BrassCraft Manufacturing _____

B. Conbraco Industries _____

C. Lee Brass Company _____

D. Lyall, R.W. & Company _____

E. McDonald, A.Y. Mfg. Co. _____

F. Mueller Co. _____

G. Perfection Corporation _____

H. Xomox Corporation _____

I. Other: _____

2.4 Liquefied-Petroleum Gas Pressure Regulators

A. Canadian Meter Company Inc. _____

B. Eaton Corporation _____

C. Harper Wyman Co. _____

D. Maxitrol Company _____

E. SCP, Inc. _____

F. Other: _____

2.5 Liquefied-Petroleum Dielectric Fittings

A. Capitol Manufacturing Company _____

B. Central Plastics Company _____

C. Hart Industries International, Inc. _____

D. McDonald A.Y. Mfg. Co. _____

E. Watts Regulator Co. _____

F. Wilkins; Zurn Plumbing _____

- G. Advance Products & Systems, Inc. ____
- H. Calpico Inc. ____
- I. Pipeline Seal and Insulator, Inc. ____
- J. Other: _____

2.6 Refrigerants

- A. Atofina Chemicals, Inc. ____
- B. DuPont Company ____
- C. Honewell, Inc. ____
- D. INEOS Fluor Americas ____
- E. Other: _____

2.7 Duct Liner

- A. CertainTeed Corp. ____
- B. Johns Manville, Inc. ____
- C. Knauf Insulation ____
- D. Owens Corning ____
- E. Other: _____

2.8 Duct Double-Wall Rectangular

- A. McGill Airflow LLC. ____
- B. MKT Metal Manufacturing ____
- C. Set Duct Manufacturing ____
- D. Sheet Metal Connectors, Inc. ____
- E. Other: _____

2.9 Duct Round and Flat-Oval

- A. Eastern Sheet Metal ____

- B. McGill AirFlow ____
- C. Semco Inc. ____
- D. Universal Spiral Air ____
- E. Other: _____

2.10 Duct Double-Wall Round and Flat-Oval

- A. Eastern Sheet Metal ____
- B. McGill AirFlow ____
- C. Semco Inc. ____
- D. Universal Spiral Air ____
- E. Other: _____

2.11 Manufactured HVAC Casings

- A. Vibro-Acoustics ____
- B. Semco ____
- C. Ruskin ____
- D. Kinetics Noise Control ____
- E. Other: _____

2.12 Air Duct Accessories Manual Dampers

- A. Air Balance, Mestek Inc. ____
- B. American Warming ____
- C. Flexmaster U.S.A. ____
- D. Greenheck ____
- E. McGill AirFlow ____
- F. Metalaire, Inc. ____
- G. Nailor Industries ____
- H. Pottorff ____

- I. Ruskin ____
- J. Trox USA Inc. ____
- K. United Enertech ____
- L. Vent Products ____
- M. Other: _____

2.13 Air Duct Accessories Fire and/or Smoke Dampers

- A. Air Balance, Mestek Inc. ____
- B. Cesco Products, Mestek Inc. ____
- C. Greenheck ____
- D. Nailor Industries ____
- E. Pottorff ____
- F. Ruskin ____
- G. United Enertech ____
- H. Vent Products ____
- I. Other: _____

2.14 Air Duct Accessories Flange Connectors

- A. Ductmate Industries, Inc. ____
- B. Nexus PDQ; Shilco Holdings Inc. ____
- C. Ward Industries, Inc.: Hart & Cooley, Inc. ____
- D. Other: _____

2.15 Air Duct Accessories Silencers

- A. Kineteics Noise Control ____
- B. McGill AirFlow ____
- C. Ruskin ____
- D. Semco ____

- E. Price-HVAC _____
- F. Vibro-Acoustics _____
- G. Other: _____

2.16 Air Duct Accessories Turning Vanes

- A. Ductmate Industries, Inc. _____
- B. Duro Dyne Inc. _____
- C. Metalaire, Inc. _____
- D. Semco Incorporated _____
- E. Ward Industries, Inc.; Hart & Cooley, Inc. _____
- F. Other: _____

2.17 Air Duct Accessories Remote Damper Operators

- A. Pottorff _____
- B. Ventfabrics, Inc. _____
- C. Young Regulator Company _____
- D. Other: _____

2.18 Air Duct Accessories Duct-Mounted Access Doors

- A. American Warming and Ventilating; Mestek, Inc. _____
- B. Cesco Products; Mestek, Inc. _____
- C. Ductmate Industries, Inc. _____
- D. Flexmaster U.S.A., Inc. _____
- E. Greenheck Fan Corporation _____
- F. McGill AirFlow LLC _____
- G. Nailor Industries Inc _____
- H. Pottorff _____
- I. Ruskin _____

- J. Ventfabrics, Inc. ____
- K. Ward Industries, Inc.; Hart & Cooley, Inc. ____
- L. Other: _____

2.19 Air Duct Accessories Flexible Connectors

- A. Ductmate Industries, Inc. ____
- B. Duro Dyne Inc. ____
- C. Ventfabrics, Inc. ____
- D. Ward Industries, Inc.; Hart & Cooley, Inc. ____
- E. Other: _____

2.20 Air Duct Accessories Flexible Ducts

- A. Flexmaster U.S.A. ____
- B. Thermaflex ____
- C. Other: _____

2.21 HVAC In-Line Centrifugal Fans

- A. Greenheck ____
- B. Loren Cook Company ____
- C. Penn-Barry ____
- D. Other: _____

2.22 HVAC Ceiling-Mounting Power Ventilators

- A. Breidert Air Products ____
- B. Broan Inc. ____
- C. Greenheck ____
- D. Loren Cook Company ____
- E. Penn-Barry ____

F. Other: _____

2.23 Commercial Air Curtains

A. Berner International _____

B. Mars Air Systems _____

C. Powered Aire Inc. _____

D. Other: _____

2.24 Air Terminal Units

A. AirFixture _____

B. Anemostat, Mestek Company _____

C. Johnson Controls _____

D. Krueger _____

E. Nailor Industries _____

F. Price Industries _____

G. Titus _____

H. Trane _____

I. Tuttle & Bailey _____

J. Other: _____

2.25 Diffusers, Registers, and Grilles

A. Krueger _____

B. Price _____

C. Tuttle and Bailey _____

D. Titus _____

E. Nailor _____

F. Other: _____

2.26 Packaged Air Handling Units

A.	AAON _____	Breakout Cost: _____
B.	Trane Horizon _____	Breakout Cost: _____
C.	Valent; a Division of Greenheck _____	Breakout Cost: _____
D.	Other: _____	

2.27 Split System AC Units

- A. Enviromaster International _____
- B. Carrier _____
- C. Daikin/McQuay _____
- D. LG Electronics _____
- E. Mitsubishi _____
- F. Sanyo Fisher _____
- G. Trane _____
- H. JCI/York _____
- I. Other: _____

2.28 Unit Heaters

- A. Berko _____
- B. Daikin/McQuay _____
- C. Indeeco _____
- D. Markel _____
- E. Marley _____
- F. QMark _____
- G. Trane _____
- H. Other: _____

PART 3 - EXECUTION

3.1 Sub-Contractor / Supplier

- A. Insulation _____
- B. Sheet Metal _____
- C. Testing, Adjusting, and Balancing _____

3.2 Mechanical Contractor: _____

- A. Authorized Signature: _____
- B. Date: _____

3.3 Shop drawings and operating instructions will be required on each applicable item of equipment. It is to the Contractor's advantage to submit these for approval as soon as possible after the Contract is awarded.

END OF SECTION 23 0000

SECTION 23 0500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
1. Piping materials and installation instructions common to most piping systems.
 2. Sleeves.
 3. Stack-sleeve fittings.
 4. Escutcheons.
 5. Grout.
 6. HVAC demolition.
 7. Equipment installation requirements common to equipment sections.
 8. Painting and finishing.
 9. Supports and anchorages.

1.2 QUALITY ASSURANCE

- A. Provide HVAC systems, equipment, and materials in accordance with North Carolina Mechanical Code and other applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- D. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.
- E. Pipe Sizes: Where pipe sizes indicated on drawings are unavailable, installing contractor must provide next available pipe size up.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

- C. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

1.4 COORDINATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of HVAC systems. For clarity of intent and for reasons of software limitations, graphic representations of systems or portions of systems may deviate from their intended or actual construction. Drawings are not fabrication drawings and are diagrammatic to indicate the general extent of work. Coordinate with all other trades to meet installation requirements specified in Division 23 sections. Include all necessary components, offsets, and fittings which are required due to the work of other trades, space constraints, or other field conditions.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Refer to architectural documents for "Access Door and Frame" requirements.
- D. Dead load placement and attachment method of hangers and pipe supports for HVAC equipment, piping, ductwork, and other associated devices shall be coordinated with respective contractors of supporting structural members (Through the CM / GC). HVAC loads shall be supported from structural members that are designed for additional equipment loads. Locate all hangers from joists or beams in accordance with structural details (See structural drawings). This may require reinforcing of joists for hanger loads not located at joist panel points and must be provided per structural details and included in the scope of the subcontractor responsible for the system being hung.
- E. Hanging devices, supports, anchors, or similar attachments shall not be supported directly from metal decks unless approved by the structural engineer of record.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

2.2 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for Joining Plastic Piping:
 - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Plastic.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 SLEEVES

- A. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.5 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.6 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.

- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.
- F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

2.7 FLOOR PLATES

- A. Description: Manufactured floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
- B. One-Piece Floor Plates: Cast-iron flange.
- C. One-Piece Floor Plates: Cast-iron flange.
- D. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.8 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.9 MECHANICAL ROOF PENETRATIONS

- A. Pipe Curbs for Single or Multiple Pipe Penetrations: Prefabricated heavy-gage galvanized steel or aluminum curb with mitered and welded corners, minimum 1 1/2 inch thick rigid fiberglass insulation adhered to inside walls, built-in cant and mounting flange for roof decks, wood nailer, and acrylic clad ABS plastic cover(s), PVC boot(s), and stainless steel clamps.. Size as required to suit roof opening and piping. Overall minimum height shall be 12 inches above roof insulation. Provide curbs with level tops and bottoms to match roof slope. Pate or equivalent.
- B. Pipe Curbs for Single Pipe Penetrations: All roof pipe penetrations up to 10" O.D. shall be flashed and sealed using a Pate or equivalent pipe seal, consisting of a spun aluminum base having a minimum five inch roof surface flange, a stepped polyvinyl chloride boot to be secured to the base and the pipe with adjustable stainless steel clamps as furnished.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

- A. Coordinate with general contractor for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - 2. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 3. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.
 - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.

3.3 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall in Finished Spaces: One-piece, deep-pattern type.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

3.4 FLOOR PLATE INSTALLATION

- A. Install floor plates for piping penetrations of equipment-room floors.
 - 1. New Piping: One-piece, floor-plate type.
 - 2. Existing Piping: Split-casting, floor-plate type.

3.5 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Refer to architectural documents for "Joint Sealant" requirements.
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to architectural documents for "Penetration Firestopping" requirements.

3.6 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Refer to architectural documents for "Sheet Metal Flashing and Trim" requirements
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to architectural documents for "Penetration Firestopping" requirements.

3.7 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.8 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls Above Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves, galvanized-steel wall sleeves, or galvanized-steel-pipe sleeves.
 - 2. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
 - 3. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6: Stack-sleeve fittings.
 - 4. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.

3.9 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.10 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of mechanical equipment.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.

- H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.11 PAINTING

- A. Refer to architectural documents for "Exterior Painting" and "Interior Painting" requirements.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.13 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
 - 1. Clean surfaces that will come into contact with grout.
 - 2. Provide forms as required for placement of grout.
 - 3. Avoid air entrapment during placement of grout.
 - 4. Place grout, completely filling equipment bases.
 - 5. Place grout on concrete bases and provide smooth bearing surface for equipment.
 - 6. Place grout around anchors.
 - 7. Cure placed grout.

3.14 MECHANICAL ROOF PENETRATIONS

- A. Install mechanical roof penetrations in accordance with roof curb manufacturer's recommendations and in strict compliance with roofing manufacturer's requirements.
 - 1. Roofs with Warranty: Roof penetrations and curbs shall be installed in such a manner to maintain roofing warranty.
- B. Pipe Curbs for Pipe Penetrations: Secure boot to curb base and secure boot to pipe with adjustable stainless steel clamps.

3.15 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, dampers or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors.

Access doors required in rated walls and ceiling shall bear the same rating. Refer to architectural documents for "Access Door and Frame" requirements.

1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
2. Adjust hardware and panels after installation for proper operation.

END OF SECTION 23 0500

SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.
- B. For motors using variable frequency controller, motors to be designed for such application and suitable for use throughout speed range without overheating.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
 - 1. Provide premium efficient motors where scheduled or when used with a variable frequency controller.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Class B.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Manufacturer's standard material.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with controller.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
 2. Split phase.
 3. Capacitor start, inductor run.
 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 ELECTRONIC COMMUTATION MOTOR (ECM)

- A. Description: Motor to be an electronic commutation motor (ECM) specifically designed for direct drive fan applications. Motors shall be permanently lubricated with heavy-duty ball bearings to match the fan load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0513

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SECTION 23 0529 - 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, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following hangers and supports for HVAC system piping and equipment:
 - 1. Metal pipe hangers and supports.
 - 2. Metal framing systems.
 - 3. Thermal-hanger shield inserts.
 - 4. Fastener systems.
 - 5. Pipe stands.
 - 6. Equipment supports.
 - 7. Service platforms.
- B. Related Sections include the following:
 - 1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
 - 3. Division 23 Section(s) "Metal Ducts" for duct hangers and supports.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design equipment supports and equipment service platforms, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 INFORMATIONAL SUBMITTALS

- A. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Equipment service platforms.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.3 THERMAL-HANGER SHIELD INSERTS

- #### A. Insulation-Insert Material for Cold Piping:
- ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.

- B. For Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Indoor Applications: Zinc-coated steel.
 - 2. Outdoor Applications: Stainless steel.

2.5 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support piping.
- B. Compact Pipe Stand:
 - 1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 3. Hardware: Galvanized steel or polycarbonate.
 - 4. Accessories: Protection pads.
- C. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support.
 - 1. Base: Plastic.
 - 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, channels or continuous-thread rods.
 - 3. Horizontal Member: Cadmium-plated-steel or stainless-steel channel or rod with plastic or stainless-steel, roller-type pipe support.

2.6 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 EQUIPMENT SERVICE PLATFORMS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Miro Industries, Inc.
 2. PHP Systems.
 3. Rooftop Support Systems.
- B. Description: Platforms made to crossover pipes, ducts, obstructions, and access elevated equipment, allowing for thermal expansion and thermal contraction of supported components. Platforms are to meet project specific requirements and OSHA 1910 Subpart D standards for the build requirements, and the following:
1. Deck Bases: Polycarbonate or hot-dipped galvanized steel.
 2. Metal Components: Hot-dipped galvanized steel.
 3. Walking Surfaces: Bar grating with serrated surface. Width as required to avoid pipes, ducts, obstructions, and equipment service clearances.
 4. Railings: Railings shall be provided on all stairways, ramps, and platforms having 4 or more risers. Railings shall be removable where they interfere with equipment service clearances.
 5. Service platforms shall take into consideration weight of personnel and equipment replacement parts such as compressors, motors, and fans.
 6. Service platforms that are exposed to wind shall be designed and installed to resist wind pressures determined in accordance with International Building Code, and ASCE 7.
 7. Service platforms that are subject to snow and ice loads shall be designed and installed in accordance with International Building Code, and ASCE 7.
 8. The design requirements for stairways, ramps, supports, and attachments shall be supported by one of the following methods:
 - a. Project-specific design and documentation submitted for approval to the authority having jurisdiction by a registered design professional.
 - b. Submittal of manufacturer's certification that the component is qualified by an independent third party via either analysis or testing in accordance with industry standards.

2.8 MATERIALS

- A. Carbon Steel: ASTM A 1011/A 1011M.
- B. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- C. Stainless Steel: ASTM A 240/A 240M.
- D. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and metal framing systems and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use thermal-hanger shield inserts for insulated piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 - 3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
 - 4. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 - 6. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 - 7. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 8. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
- I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 4. C-Clamps (MSS Type 23): For structural shapes.
 5. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 6. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 7. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- M. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
- N. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
1. Use powder-actuated fasteners only in concrete construction that is suitable for their installation.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- E. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth surface.
- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

- b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 5. Insert Material: Length at least as long as protective shield.
 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 EQUIPMENT SERVICE PLATFORMS

- A. A manufacturer representative shall perform on-site field measurements, coordinate design and layout, designate and tag products based on project conditions.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for each substrate under the project conditions.
- C. Place the supports:
 1. Center each stand beneath the component so supports are aligned.
 2. Set components in or on support without dropping or causing undue impact.

3.5 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches maximum.
- C. Service Platforms: Adjust height of each support to achieve proper height and level before installing supported item.
 - 1. Level hangers, rollers or struts before installing component.
 - 2. Make final height adjustments to provide even distribution of load on all supports.

3.7 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 0529

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SECTION 23 0548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Isolation pads.
 - 2. Isolation mounts.
 - 3. Freestanding spring isolators.
 - 4. Elastomeric hangers.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ace Mountings Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. California Dynamics Corporation.
 - 4. Isolation Technology, Inc.
 - 5. Kinetics Noise Control.
 - 6. Mason Industries.
 - 7. Vibration Eliminator Co., Inc.
 - 8. Vibration Isolation.
 - 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant.

- C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
 - 1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - 2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
 - 1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
 - 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- E. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

END OF SECTION 23 0548

SECTION 23 0553 - 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, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Duct labels.
 - 5. Stencils.
 - 6. Ceiling markers.
 - 7. Warning tags.

1.3 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: Black.
 - 3. Background Color: White.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 5. 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.
 - 6. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- B. Label Content: Include equipment's Drawing designation or unique equipment number.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 - 1. Letter Color: White.
 - 2. Background Color: Black.
 - 3. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 4. 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.
 - 5. Fasteners: Stainless-steel rivets.
 - 6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Self-Adhesive Pipe Labels: Printed plastic label with contact-type, permanent-adhesive backing. Include wrap around flow arrow tape with contact-type, permanent-adhesive backing.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

- A. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- B. 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.
- C. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- D. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2.5 STENCILS

- A. Stencils: Prepared with minimum letter height minimum letter height of 1 inch for equipment labels.
 - 1. Stencil Material: Fiberboard or metal.
 - 2. Stencil Paint: Exterior, gloss, black enamel unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - 1. Size: 3 by 5-1/4 inches minimum.
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Yellow background with black lettering.

2.7 CEILING MARKERS

- A. Self-Adhesive Ceiling Markers: Printed with contact-type, permanent-adhesive backing.
 - 1. Background Color: White.
 - 2. Letter Color: Black.
 - 3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 120 inches 1/2 inch for viewing distances greater than 120 inches.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.
- C. Stenciled Equipment Label Option: Stenciled labels may be provided for outdoor equipment, equipment located within mechanical rooms, and equipment installed above ceilings, instead of manufactured equipment labels, at Installer's option.

3.3 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is concealed above ceilings or exposed in unfinished mechanical rooms; accessible maintenance spaces such as shafts, tunnels, and plenums as follows:
 - 1. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 2. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 3. Near major equipment items and other points of origination and termination.
 - 4. Spaced at maximum intervals of 50 feet along each run.
- B. Locate pipe labels where piping is exposed in finished spaces as follows:
 - 1. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

3.4 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts.
- B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 CEILING MARKER INSTALLATION

- A. Install ceiling markers on t-bar ceiling grids and ceiling access panels to indicate locations of equipment,.

3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems.
 - 2. Testing, Adjusting, and Balancing Equipment.
 - 3. Testing, Adjusting, and Balancing Existing Systems and Equipment.

1.3 DEFINITIONS

- A. NEBB: National Environmental Balancing Bureau.
- B. TAB: Testing, adjusting, and balancing.
- C. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Needs for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 24 hours after time of bidding, submit to the engineer documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in the "Quality Assurance" Article.
- B. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

- C. Existing Systems Examination Report: Prior to the start of demolition, submit the existing systems examination report indicating the operating condition of existing equipment and the results of the measurements taken, indicating deficiencies.
- D. Certified TAB reports.
- E. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.6 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by , NEBB.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7 - "System Balancing."

1.7 FIELD CONDITIONS

- A. Owner Occupancy: Owner will occupy the site and existing building during TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.8 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Perform TAB after leakage and pressure tests on distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, engage a TAB specialist within 75 miles of the project site.

3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine equipment performance data.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- E. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- F. Examine test reports specified in individual system and equipment Sections.
- G. Examine HVAC equipment and verify that equipment with functioning controls is ready for operation.
- H. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- I. Examine operating safety interlocks and controls on HVAC equipment.
- J. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Duct systems are complete with terminals installed.
 - b. Volume, smoke, and fire dampers are open and functional.
 - c. Clean filters are installed.
 - d. Fans are operating, free of vibration, and rotating in correct direction.

- e. Automatic temperature-control systems are operational.
- f. Ceilings are installed.
- g. Windows and doors are installed.
- h. Suitable access to balancing devices and equipment is provided.
- i. Verify field quality-control testing, cleaning, and adjusting reports prepared by factory-authorized service representatives, system, and equipment installers specified in individual Sections have been performed.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 0700 "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.

- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 23 3113 "Metal Ducts."
- M. After completion of balancing systems, all adjustable sheaves to be replaced with fixed sheaves.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Measure maximum demand control ventilation outdoor airflows.
5. Measure minimum demand control ventilation outdoor airflows.
6. Mark all final settings.
7. Test system in economizer mode. Verify proper operation and adjust if necessary.
8. Measure and record all operating data.
9. Record final fan-performance data.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Single Zone Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance systems similar to constant-volume air systems.
 2. Set air inlets, air outlets, and supply fan at full-airflow condition.
 3. Adjust air outlets to indicated airflow.
 4. Readjust fan airflow for final maximum readings.
 5. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 6. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
- B. Multi Zone Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
 2. Verify that the system is under static pressure control.
 3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.

- f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
- 5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
- 6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
- 7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
- 8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
- 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.8 PROCEDURES FOR MOTORS

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

3.9 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.

3.10 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Prior to demolition of air and water HVAC distributions systems and equipment, measure and record existing supply air, return air, outdoor air, exhaust air, and water flow conditions for all equipment, ductwork and hydronic piping systems serving area being modified during the project.
 1. Measure and record the operating speeds, pressures, temperatures, and flow rates of existing equipment.
 2. Measure and record the flow rates at interconnection points between existing and new work.
 3. Measure voltage and amperage of effected equipment. Compare the values to nameplate information.
 4. Measure and record the refrigerant charge.
 5. Document the conditions of filters.
 6. Document the conditions of fans.
 7. Document the conditions of coils.
 8. Document the conditions of compressors.
 9. Document the conditions of the drain pan and condensate-drain trap.
 10. Document the conditions of bearings and other lubricated parts for proper lubrication.
 11. Report and take photos on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. After revisions are complete, measure all the HVAC air and water systems modified and restore the systems to their original or scheduled capacities.
 1. Compare the indicated flow rates of the renovated work to the measured flow rates and determine the new equipment flow rates.
 2. Verify that the indicated flows of the renovated work result in conditions that are within the acceptable limits defined by equipment manufacturer.
 3. Re-measure, record and verify the flow rates at interconnection points between existing and new work.
 4. If calculations increase or decrease the flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
 5. Balance each affected branch and main.

3.11 TOLERANCES

- A. Set HVAC system's flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 - 2. Air Outlets and Inlets: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.12 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Equipment operating curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB specialist.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB supervisor who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - 12. Nomenclature sheets for each item of equipment.
 - 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:

- a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Fan drive settings including settings and percentage of maximum pitch diameter.
 - e. Settings for supply-air, static-pressure controller.
 - f. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Duct, outlet, and inlet sizes.
 3. Terminal units.
 4. Balancing stations.
 5. Position of balancing devices.
- E. Air System Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 2. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Discharge static pressure in inches wg.
 - d. Filter static-pressure differential in inches wg.
 - e. Outdoor airflow in cfm.
 - f. Return airflow in cfm.
 - g. Minimum Outdoor Airflow-air damper position.
 - h. Maximum Outdoor Airflow-air damper position.
 - i. Return-air damper position.
- F. Coil Test Reports: In addition to manufacturer's startup equipment reports, include the following:
 1. Coil Data:
 - a. System identification.
 - b. Location.
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.

- b. Air pressure drop in inches wg.
 - c. Outdoor-air, wet- and dry-bulb temperatures in deg F.
 - d. Return-air, wet- and dry-bulb temperatures in deg F.
 - e. Entering-air, wet- and dry-bulb temperatures in deg F.
 - f. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - g. Refrigerant expansion valve and refrigerant types.
 - h. Refrigerant suction pressure in psig.
 - i. Refrigerant suction temperature in deg F.
- G. Gas- and Oil-Fired Heat Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
 - 1. Unit Data:
 - a. System identification.
 - b. Location.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air pressure drop in inches wg.
 - c. Entering-air temperature in deg F.
 - d. Leaving-air temperature in deg F.
 - e. Low-fire fuel input in Btu/h.
 - f. High-fire fuel input in Btu/h.
 - g. Manifold pressure in psig.
 - h. High-temperature-limit setting in deg F.
- H. Electric-Coil Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
 - 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Number of stages.
 - d. Connected volts, phase, and hertz.
 - e. Rated amperage.
 - f. Airflow rate in cfm.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-air temperature in deg F.
 - c. Leaving-air temperature in deg F.
 - d. Voltage at each connection.
 - e. Amperage for each phase.
- I. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.

- e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
 - f. VFD Maximum Speed Hz.
 - g. VFD Minimum Speed Hz.
 - h. ECM Maximum Speed Hz.
 - i. ECM Minimum Speed Hz.
- J. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
- 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- K. Air-Terminal-Device Reports:
- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.

- h. Size.
 - i. Effective area in sq. ft..
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- L. Compressor and Condenser Reports: For refrigerant side of air-cooled condensing units, include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Unit make and model number.
 - d. Low ambient temperature cutoff in deg F.
- M. Instrument Calibration Reports:
 - 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.13 VERIFICATION OF TAB REPORT

- A. Refer to Division 01 Section "General Commissioning Requirements" for verification of TAB report procedures.
- B. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to documentation, non-conformance, and approval of tests.

3.14 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

END OF SECTION 23 0593

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SECTION 23 0700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section includes insulation materials for HVAC systems.
- B. Related Sections:
 - 1. Division 22 Section "Plumbing Insulation."
 - 2. Division 23 Section "Metal Ducts" for duct liners.

1.3 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate clearance requirements with equipment Installer for equipment insulation application.

- D. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CertainTeed Corporation.
 - 2. Johns Manville; a Berkshire Hathaway company.
 - 3. Knauf Insulation.
 - 4. Owens Corning.
- B. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- C. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Provide FSK for ductwork applications.
- G. Mineral-Fiber, Pipe, Duct and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Provide FSK for ductwork applications, as scheduled.

2.2 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1 -hour fire rating by a NRTL acceptable to authority having jurisdiction.

2.3 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

2.4 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 200 deg F.
 - 3. Solids Content: 63 percent by volume and 73 percent by weight.
 - 4. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK Jacket Flashing Sealants:

1. Products:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Adhesive: As recommended by jacket material manufacturer.
 - 2. Color: White.
 - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, traps, and mechanical joints.
- C. Self-Adhesive Outdoor Jacket: Minimum 40-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with aluminum-foil facing.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Polyguard; Alumaguard.
 - b. MFM Building Products; Flex Clad 400

2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 11.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 6.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - 1. Width: 2 inches.
 - 2. Thickness: 6 mils.

3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch or 3/4 inch wide with wing or closed seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel; fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel; fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel, aluminum, or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

- a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- F. Keep insulation materials dry during application and finishing.

- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant.

3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 4. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 5. Seal jacket to wall flashing with flashing sealant.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Refer to architectural documents for "Penetration Firestopping" requirements.
- D. Insulation Installation at Floor Penetrations:
1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 2. Pipe: Install insulation continuously through floor penetrations.
 3. Seal penetrations through fire-rated assemblies. Refer to architectural documents for "Penetration Firestopping" requirements.

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 4. For mineral fiber insulation, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

3.6 MINERAL-FIBER INSULATION INSTALLATION

- A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
 4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- C. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, trapeze hanger bars, and duct flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- D. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, trapeze hanger bars, and duct flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
2. Fill inside of fitting jackets to prevent collapse of jacket.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Refer to architectural documents for "Penetration Firestopping" requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation: Insulate the following in accordance with insulation schedule:
 1. Supply air.
 2. Return air.
 3. Relief air.
 4. Exhaust air.
 5. Slot and linear diffuser plenums.
- B. Items Not Insulated:
 1. Factory-insulated flexible ducts.
 2. Factory-insulated plenums and casings, except as indicated.
 3. Flexible connectors.
 4. Vibration-control devices.
 5. Factory-insulated access panels and doors.
 6. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 7. Exposed supply and return metal ducts within rooms they are serving except mechanical rooms.
- C. Definitions:
 1. Concealed: Within enclosure, or above solid ceiling, and not visible from any direction below.
 2. Exposed: In rooms with no ceilings or with partial ceilings (i.e. "cloud type ceilings") and visible from any direction below.
 3. Finished Spaces: Spaces with room finishes accessible by building occupants.
 4. Unfinished Spaces: Spaces with no or limited room finishes accessible by building maintenance and support staff only.

3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed relief, supply and return air duct and plenum insulation shall be the following:
 1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.

- B. Concealed exhaust-air duct and plenum insulation between isolation damper and penetration of building exterior shall be the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.
- C. Exposed relief, supply and return air duct insulation within mechanical rooms shall be the following:
 - 1. Mineral-Fiber Board with FSK Jacket (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Duct, Pipe and Tank with FSK Jacket (For Round or Flat Oval Duct Applications): 1-1/2 inches thick.
- D. Exposed exhaust-air duct insulation within mechanical rooms between isolation damper and penetration of building exterior shall be the following:
 - 1. Mineral-Fiber Board with FSK Jacket (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Duct, Pipe and Tank with FSK Jacket (For Round Duct Applications): 1-1/2 inches thick.

3.11 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Outdoor duct and plenum insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches(50 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density, with protective field applied jacket.

3.12 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable insulation materials and thicknesses are identified for each piping system and pipe size range.
 - 1. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.13 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F(16 Deg C):
 - 1. All Pipe Sizes Exposed in Mechanical Rooms and Concealed Locations: Insulation shall be one of the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch(25 mm) thick.
 - 2. All Pipe Sizes Exposed in Finished Spaces: Insulation shall be following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch(25 mm) thick.
- B. Refrigerant Suction and Hot-Gas Piping: Insulation shall be the following:

1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping: Insulation shall be the following:

1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. Pipe Fittings with Mineral Fiber Insulation:

1. PVC Fitting Covers: 20 mils thick, white.

- C. Exposed Vertical Piping within 8 feet of Floor shall be the following:

1. PVC: 30 mils thick, white.

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. Ducts and Plenums:

1. Cover mineral fiber insulation with the following:
 - a. Aluminum Jacket: 20-gauge with stucco embossed face.

- C. Piping:

1. Cover mineral fiber insulation with the following:
 - a. PVC: 30 mils thick, white.

END OF SECTION 23 0700

SECTION 23 0800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.
 - 2. Division 26 Section "Commissioning of Electrical Systems" for electrical systems commissioning requirements.

1.2 GENERAL COMMISSIONING REQUIREMENTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for general commissioning requirements, additional definitions, coordination, documentation procedures, process, and responsibilities.

1.3 DEFINITIONS

- A. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. This includes but is not limited to two-way radios, meters, and data recorders.
- B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for documentation procedures and information to be provided to the CxA.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Contractor's Responsibilities.

3.3 EQUIPMENT SUPPLIERS RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Equipment Suppliers Responsibilities.

3.4 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.5 OWNER'S REPRESENTATIVE'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Representative's Responsibilities.

3.6 ARCHITECT/ENGINEERS (AE) RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Architecture/Engineers Responsibilities.

3.7 CONSTRUCTION MANAGER'S (CM) RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Construction Manager's Responsibilities.

3.8 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.9 TESTING PREPARATION

- A. CxA to receive certified submittals from contractor that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

- B. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.10 TESTING, ADJUSTING AND BALANCING VERIFICATION

- A. Testing, Adjusting, and Balancing for HVAC Acceptance Procedures: Testing requirements are specified in testing, adjusting, and balancing for HVAC specification sections.

3.11 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. HVAC Power Ventilator Testing and Acceptance Procedures: Testing requirements are specified in HVAC power ventilator specification sections.
- B. Air Terminal Unit Testing and Acceptance Procedures: Testing requirements are specified in air terminal unit specification sections.
- C. Air-Handling Unit Testing and Acceptance Procedures: Testing requirements are specified in air-handling unit specification sections.
- D. Split System Air Conditioners and Acceptance Procedures: Testing requirements are specified in split system air conditioners specification sections.
- E. Fan Coil Unit Testing and Acceptance Procedures: Testing requirements are specified in fan coil unit specification sections.

3.12 INTEGRATED AUTOMATION FACILITY CONTROL TESTING PROCEDURES

- A. Integrated Automation Facility Control Acceptance Procedures: Testing requirements are specified in integrated automation facility control specification sections.

3.13 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to documentation, non-conformance, and approval of tests.

3.14 DEFERRED TESTING

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.

END OF SECTION 23 0800

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SECTION 23 1126 - FACILITY LIQUEFIED-PETROLEUM GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. For Piping Containing Only Vapor:
 - a. Piping and Valves: 125 psig unless otherwise indicated.
- B. LPG System Pressure within Buildings: One pressure range. 0.5 psig or less.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Indicate pressure ratings and capacities.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For LPG equipment and accessories to include in emergency, operation, and maintenance manuals.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing LPG piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store pipes and tubes with protective PE coating to avoid damaging coating and protect from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing LPG Service: Do not interrupt LPG service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of LPG supply according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of LPG service.
 - 2. Do not proceed with interruption of LPG service without Construction Manager's written permission.

1.9 COORDINATION

- A. Coordinate the installation of the liquefied-petroleum gas service with civil and the liquefied-petroleum storage tank provider.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel, Schedules 40 and 80, 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. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.

- d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground, and stainless steel underground.
5. 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.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

- 1. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
- 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. Y-Pattern Strainers:

- 1. Body: ASTM A126, 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: 40 -mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
- 4. CWP Rating: 125 psig.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for LPG.

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.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Manual Gas Shutoff Valve Schedules" below for where each valve type is applied in various services.

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

- 1. CWP Rating: 125 psig.
- 2. Threaded Ends: Comply with ASME B1.20.1.
- 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
- 4. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.

5. Service Mark: Valves 1-1/4 inch to NPS 2 shall have initials "WOG" permanently marked on valve body.
- C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 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: Initials "WOG" shall be permanently marked on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 2. Body: Bronze, complying with ASTM B584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded
 8. CWP Rating: 600 psig.
 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for LPG service with "WOG" indicated on valve body.
- E. Bronze Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lee Brass Company.
 - b. McDonald, A. Y. Mfg. Co.
 2. Body: Bronze, complying with ASTM B584.
 3. Plug: Bronze.
 4. Ends: Threaded or flanged.
 5. Operator: Square head or lug type with tamperproof feature where indicated.
 6. Pressure Class: 125 psig.
 7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 8. Service: Suitable for LPG service with "WOG" indicated on valve body.
- F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McDonald, A. Y. Mfg. Co.

- b. Mueller Co.; Gas Products Div.
 - c. Xomox Corporation; a Crane company.
- 2. Body: Cast iron, complying with ASTM A126, Class B.
 - 3. Plug: Bronze or nickel-plated cast iron.
 - 4. Seat: Coated with thermoplastic.
 - 5. Stem Seal: Compatible with LPG.
 - 6. Ends: Threaded or flanged.
 - 7. Operator: Square head or lug type with tamperproof feature where indicated.
 - 8. Pressure Class: 125 psig.
 - 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - 10. Service: Suitable for LPG service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:

- 1. Single stage and suitable for LPG.
- 2. Steel jacket and corrosion-resistant components.
- 3. Elevation compensator.
- 4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Appliance Pressure Regulators: Comply with ANSI Z21.18.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.
 - e. SCP, Inc.
- 2. Body and Diaphragm Case: Die-cast aluminum.
- 3. Springs: Zinc-plated steel; interchangeable.
- 4. Diaphragm Plate: Zinc-plated steel.
- 5. Seat Disc: Nitrile rubber.
- 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
- 7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
- 8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - f. Wilkins; Zurn Plumbing Products Group.
2. Standard: ASSE 1079.
3. Pressure Rating: 150 psig
4. Combination fitting of copper alloy and ferrous materials.
5. Insulating materials suitable for LPG.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - d. Wilkins; Zurn Plumbing Products Group.
1. Pressure Rating: 150 psig
2. Combination fitting of copper alloy and ferrous materials.
3. Insulating materials suitable for LPG.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
2. Pressure Rating: 150 psig
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for LPG.
6. Combination fitting of copper alloy and ferrous materials.

2.7 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to civil documents for "Earth Moving" requirements for excavating, trenching, and backfilling.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off LPG to premises or piping section.
- B. Inspect LPG piping according to the International Fuel Gas Code to determine that LPG utilization devices are turned off in piping section affected.
- C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR 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 were 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. Install underground, LPG piping buried at least 36 inches below finished grade. Refer to civil documents for "Earth Moving" requirements for excavating, trenching, and backfilling.
 - 1. If LPG piping is installed less than 36 inches below finished grade, install it in containment conduit.
- D. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- E. Locate valves for easy access.
- F. Install fittings for changes in direction and branch connections.
- G. Verify final equipment locations for roughing-in.
- H. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- I. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where readily 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.
- J. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- K. Connect branch piping from top or side of horizontal piping.
- L. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- M. Do not use LPG piping as grounding electrode.
- N. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

3.4 VALVE INSTALLATION

- A. Install manual gas shutoff valve at each gas-fired piece of equipment.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.5 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 ID 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.
- E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for LPG service. Install gasket concentrically positioned.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
 - 5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.
- C. Support horizontal piping within 12 inches of each fitting.
- D. Support vertical runs to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 CONNECTIONS

- A. Install piping adjacent to appliances to allow service and maintenance of appliances.
- B. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliances and equipment. Install union between valve and appliances or equipment.
 - 1. Install pressure regulator at connection to gas-fired appliance and equipment as required to meet maximum gas pressure requirements of that particular device.
- C. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 23 0553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.9 PAINTING

- A. Refer to architectural documents for "Exterior Painting" and "Interior Painting" requirements
- B. Paint exposed, exterior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
 - 1. Color to be safety yellow .

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.
- C. LPG piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.11 OUTDOOR PIPING SCHEDULE

- A. Underground LPG vapor piping shall be the following:
 - 1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
- B. Aboveground LPG vapor piping shall be the following:
 - 1. For NPS 2 and smaller, use steel pipe with malleable-iron fittings and threaded joints.
 - 2. For NPS 2-1/2 and larger, use steel pipe with wrought-steel fittings and welded joints.
- A. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.12 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Distribution piping valves for pipe NPS 2 and smaller shall be one of the following:
 - 1. Two-piece, full -port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- B. Distribution piping valves for pipe NPS 2-1/2 and larger shall be one of the following:
 - 1. Bronze plug valve.
 - 2. Cast-iron, nonlubricated plug valve.
- C. Valves in branch piping for single appliance shall be one of the following:
 - 1. Two-piece, full -port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.

END OF SECTION 23 1126

SECTION 23 2300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure:
 - 1. Suction Lines: 535 psig.
 - 2. Hot-Gas and Liquid Lines: 535 psig.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.8 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. Refer to architectural documents for "Roof Accessory" requirements.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8.

2.2 REFRIGERANTS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Atofina Chemicals, Inc.
 - 2. DuPont Company; Fluorochemicals Div.
 - 3. Honeywell, Inc.; Genetron Refrigerants.
 - 4. INEOS Fluor Americas LLC.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT

- A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Hot-Gas and Liquid Lines:
 - 1. NPS 2 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed, or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- B. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

- C. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Liquid lines may be installed level.
- K. When brazing or soldering, remove sight glasses. Do not apply heat near expansion-valve bulb.
- L. Seal penetrations through fire and smoke barriers according to architectural documents for "Penetration Firestopping" requirements.
- M. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- N. Seal pipe penetrations through exterior walls according to architectural documents for "Joint Sealant" requirements.
- O. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

- C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.

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REFRIGERANT PIPING
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END OF SECTION 23 2300

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SECTION 23 3113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes metal ducts for air-distribution systems.
- B. Related Sections include the following:
 - 1. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors, turning vanes, flexible ducts, and flexible connectors.

1.3 SYSTEM DESCRIPTION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Adjust duct aspect ratio as needed to meet site installation conditions. Changes to layout or configuration of duct system must be specifically approved in writing by Architect/Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 QUALITY ASSURANCE

- A. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" .
- B. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- E. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.
- E. Bird Screen: 1/2 inch mesh, 16 gage galvanized wire.

2.3 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
 - 1. Manufacturers:
 - a. CertainTeed Corp.; Insulation Group.
 - b. Johns Manville International, Inc.
 - c. Knauf Insulation.
 - d. Owens Corning.
 - 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - a. Thermal Conductivity (k-Value): 0.26 at 75 deg Fmean temperature.
 - b. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - c. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Flexible Elastomeric Duct Liner: Comply with NFPA 90A or NFPA 90B.

1. Manufacturers:
 - a. CertainTeed Corp.; Insulation Group.
 - b. Johns Manville International, Inc.
 - c. Knauf Insulation.
 - d. Owens Corning.
2. Materials: Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
 - a. Thermal Conductivity (k-Value): 0.24 at 75 deg F mean temperature.
 - b. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
 - c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel or aluminum ; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

2.4 SEALANT MATERIALS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Solids Content: Minimum 65 percent.
2. Shore A Hardness: Minimum 20.
3. Water resistant.
4. Mold and mildew resistant.
5. VOC: Maximum 75 g/L (less water).
6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
7. Service: Indoor or outdoor.
8. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Solvent-Based Joint and Seam Sealant:

1. Base: Synthetic rubber resin.
2. Solvent: Toluene and heptane.
3. Solids Content: Minimum 60 percent.
4. Shore A Hardness: Minimum 60.
5. Water resistant.
6. Mold and mildew resistant.
7. Sealant shall have a VOC content of 420 g/L or less.

8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
 9. Service: Indoor or outdoor.
 10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Install structural steel members between building structure members as required for upper attachment of hangers and supports. Use members of size and strength required for span and load. The use of joist or truss bridging for hanging and supporting is prohibited.
- C. Hanger Materials: Galvanized sheet steel, galvanized steel cables, or threaded steel rod.
1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
 3. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
 4. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.6 DUCT STANDS ABOVE GRADE

- A. General Requirements for Duct Support Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support above grade mounted ductwork.
- B. Compact Duct Stand:
 - 1. Description: Single base unit with integral channel to support duct.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 3. Hardware: Galvanized steel or polycarbonate.
- C. High-Type, Duct Stand: Assembly of base, vertical and horizontal members, and duct support.
 - 1. Base: Plastic.
 - 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, channels.
 - 3. Horizontal Member: Cadmium-plated-steel or stainless-steel channel duct support.

2.7 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" based on indicated static-pressure class and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

- c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - d. Mitered ASHRAE Type SR3-1 or ER3-1 variable inlet/outlet area with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 2. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-5, "Divided Flow Branches."
 - a. Radius Type 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type 1 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2.8 DOUBLE-WALL RECTANGULAR DUCTS AND FITTING FABRICATION

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. McGill AirFlow LLC.
 - 2. MKT Metal Manufacturing.
 - 3. Set Duct Manufacturing.
 - 4. Sheet Metal Connectors, Inc.
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for clear internal dimensions of the inner duct.
- C. Outer Duct: 18-gauge, complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- D. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b.
- E. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

2. Coat insulation with antimicrobial coating.

- G. Inner Duct: Minimum 24-gauge perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.

2.9 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
- B. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- C. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- D. Butt transverse joints without gaps and coat joint with adhesive.
- E. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- F. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
1. Fan discharges.
 2. Intervals of lined duct preceding unlined duct.
- I. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.10 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eastern Sheet Metal.
 2. McGill AirFlow Corporation.
 3. SEMCO Incorporated.
 4. Universal Spiral Air.
- B. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.
- C. Round, Longitudinal-Seam Ducts: Fabricate 12 inch and smaller ducts and drops to diffusers of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

- D. Round, Spiral Lock-Seam Ducts: Fabricate 13 inch and larger ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- E. Round, Spiral Lock-Seam Ducts: For ductwork up stream of VAV terminal units, fabricate ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- F. Flat-Oval, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- G. Duct Joints:
 - 1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - 2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
- H. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- I. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- J. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - a. Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - b. Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - c. Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 2. Round Mitered Elbows: Welded construction with metal thickness equal to or greater than that of ducts.
 - 3. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
 - 4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
 - 5. Round Elbows 12 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30 and 60 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 - 6. Round Elbows Larger Than 12 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
 - 7. Die-Formed Elbows for Sizes through 12 Inches in Diameter and all pressures 0.040 inch thick with 2-piece welded construction.
 - 8. Round Gored-Elbow Metal Thickness: Same as metal thickness or greater than that of ducts.
 - 9. Flat-Oval Elbow Metal Thickness: Same as metal thickness or greater than that of ducts.

2.11 DOUBLE-WALL ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eastern Sheet Metal.
 - b. McGill AirFlow Corporation.
 - c. SEMCO Incorporated.
 - d. Universal Spiral Air.
- B. Outer Duct: 18 gauge, complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch.3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
- C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- F. Inner Duct: Minimum 24-gauge perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.
- G. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 2. Coat insulation with antimicrobial coating.

PART 3 - EXECUTION

3.1 DUCTWORK CONSTRUCTION

- A. Provide ductwork constructed in accordance with SMACNA Duct Construction Standards but no less than the static pressure classification as indicated below.
- B. Supply Ducts:
 - 1. Ducts Connected to Fan Coil Units and Terminal Units:
 - a. Pressure Class: Positive 2-inch wg.
 - 2. Ducts Connected to Variable-Air-Volume Air-Handling Units:

- a. Pressure Class: Positive 3-inch wg.
 - 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 2-inch wg.
 - C. Return Ducts:
 - 1. Ducts Connected to Fan Coil Units and Terminal Units:
 - a. Pressure Class: Positive or negative 1-inch wg.
 - 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - 3. Ducts Connected to Equipment Not Listed above:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - D. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 2-inch wg.
 - 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - 3. Ducts Connected to Equipment Not Listed above:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - E. Liner (Where indicated on drawings):
 - 1. Sheet Metal Supply-Air Ducts: Fibrous glass, Type I, 1-inch(es) thick.
 - 2. Sheet Metal Return-Air Ducts: Fibrous glass, Type I, 1-inch(es) thick.
 - 3. Sheet Metal Exhaust-Air Ducts: Flexible elastomeric, Type II, 1-inch(es) thick.
 - 4. Sheet Metal Transfer Ducts: Fibrous glass, Type I, 1-inch(es) thick.
 - F. Double-Wall Duct Interstitial Insulation Located Indoors (Where indicated on drawings):
 - 1. Sheet Metal Supply-Air Ducts (Perforated): 1inch(es) thick 3lb/sq.ft.
 - 2. Sheet Metal Return-Air Ducts (Perforated): 1inch(es) thick 3lb/sq.ft.
 - G. Double-Wall Duct Interstitial Insulation Located Outdoors (Where indicated on drawings):
 - 1. Sheet Metal Supply-Air Ducts (Perforated): 2inch(es) thick 3lb/sq.ft.
 - 2. Sheet Metal Return-Air Ducts (Perforated): 2inch(es) thick 3lb/sq.ft.
- 3.2 DUCT INSTALLATION
- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- J. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- K. Where ducts pass through non rated interior partitions and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- L. Paint interiors of metal ducts, that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Refer to architectural documents for "Exterior Painting" and "Interior Painting" requirements.
- M. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system. Install duct mounted control dampers supplied by Temperature Control Installer.
- N. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.

3.3 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.4 DUCT CLEANLINESS REQUIREMENTS

- A. Protect duct interiors from the elements and foreign materials in accordance with the following SMACNA's "Duct Cleanliness for New Construction." Guidelines:
 - 1. Advance Level.

3.5 SEAM AND JOINT SEALING

- A. All ductwork shall be suitably cleaned and prepared, and sealant applied in strict accordance with manufacturer's instructions. Manufacturer's recommendations for cure time shall be followed before pressure testing is begun. Any additional paint or coatings must conform to manufacturer's specifications. Seal duct seams and joints as follows:
 - 1. Pressure Classification 2 and 3 Inches Water Gage: All transverse joints and longitudinal seams (SMACNA Seal Class B).
 - 2. Pressure Classification Less than 2 Inches Water Gage: Transverse joints only (SMACNA Seal Class C).

3.6 HANGING AND SUPPORTING

- A. Support ductwork with support systems indicated in SMACNA "HVAC Duct Construction Standards".
- B. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- C. Hangers Exposed to View: Steel cables, or threaded rod and angle or channel supports.
- D. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- E. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

3.7 DUCT STANDS ABOVE GRADE INSTALLATION

- A. Install above grade ductwork supports following support manufacturer guidelines.

3.8 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

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METAL DUCTS
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SECTION 23 3119.16 - MANUFACTURED HVAC CASINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Manufactured casings.
 - 2. Absorption panels.
 - 3. Interstitial insulation.
 - 4. Sealant materials.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Factory-fabricated casings.
 - 2. Absorption panels.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Sheet metal thickness(es).
 - b. Insulation.
 - c. Reinforcement and spacing.
 - d. Seam and joint construction.
 - e. Access doors including frames, hinges, and latches.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 COORDINATION

- A. Coordinate sizes and locations of steel supports. Supports are specified in Section 05 5000 "Metal Fabrications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Vibro-Acoustics.
2. Semco.
3. Ruskin.
4. Kinetics Noise Control.

2.2 PERFORMANCE REQUIREMENTS

A. HVAC Casing Acoustical Performance:

1. Octave Band, Hz	125	250	500	1000	2000	4000
Transmission Loss, dB	21	27	37	48	54	54
Absorption Coefficients	0.7	0.9	0.99	0.99	0.9	0.8

B. Absorption Panel Acoustical Performance:

1. Octave Band, Hz	125	250	500	1000	2000	4000
Absorption Coefficients	0.3	0.7	0.9	0.99	0.9	0.8

C. Structural Performance:

1. Fabricate casings to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch/foot of width.

D. Flammability and Smoke:

1. Insulation and Other Materials Exposed to the Airstream:
 - a. All materials exposed to the airstream to comply with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84.

2.3 GENERAL CASING FABRICATION REQUIREMENTS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Exterior-Surface Galvanized Coating Designation: G90.
2. Interior-Surface Galvanized Coating Designation: G90.

B. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

- C. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.
- D. Access Doors: Fabricate access doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 9-15, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 9-16, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and in accordance with pressure class of the plenum or casing section in which access doors are to be installed.
 - 1. Size: 24 by 24 inches.
 - 2. Hinges: Piano or butt hinges and latches; number and size in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 3. Latches: Wedge-lever-type latches; operable from inside and outside.
 - 4. Neoprene gaskets around entire perimeters of door frames.

2.4 MANUFACTURED CASINGS

- A. Description: Double-wall, insulated, pressurized equipment casing.
- B. Double-Wall Panel Fabrication: Exterior and interior sheet metal walls; with interstitial space filled with insulation.
 - 1. Panel Thickness: 2 inches.
 - 2. Fabricate with a minimum number of joints.
 - 3. Weld, crimp, or otherwise secure exterior and interior walls to perimeter; to interior, longitudinal channels; and to box-end internal closures. Longitudinal channels to be same metal as exterior wall. Paint welds.
 - 4. Sheet Metal Thicknesses:
 - a. Exterior Wall Thickness: 18 gauge minimum.
 - b. Interior Wall Thickness: 22 gauge minimum.
 - 5. Neoprene gasket applied around entire perimeters of panel frames.
 - 6. Outer Wall Material: Solid galvanized sheet steel.
 - 7. Inner Wall Material, Perforated: Perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.
 - 8. Fill each panel assembly with fibrous-glass insulating material that is noncombustible, inert, mildew resistant, and vermin proof and that complies with NFPA 90A.
 - 9. Fabricate panels with continuous tongue-and-groove or self-locking joints effective inside and outside each panel.
- C. Trim Items: Fabricate from a minimum of 18-gauge galvanized sheet steel, furnished in standard lengths for field cutting.

2.5 ABSORPTION PANELS

- A. Single skin panels with acoustic media within for attachment to wall surfaces.
- B. Panel Fabrication: Sheet metal panel; with interstitial space filled with insulation.
 - 1. Panel Thickness: 2 inches.

2. Secure to wall framing using self-tapping screws.
3. Sheet Metal Thicknesses:
 - a. Wall Thickness: 22 gauge minimum.
4. Wall Material, Perforated: Perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.
5. Fill each panel assembly with fibrous-glass insulating material that is noncombustible, inert, mildew resistant, and vermin proof and that complies with NFPA 90A.

2.6 INTERSTITIAL INSULATION

- A. Fibrous-Glass Insulation: Comply with maximum 25 flame-spread index and maximum 50 smoke-developed index when tested in accordance with ASTM E84.
 1. Media to be incombustible, acoustical quality, fibrous-glass insulation with long, resilient fibers bonded with a thermosetting resin.

2.7 SEALANT MATERIALS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with ASTM E84 or UL 723; certified by an NRTL.
- B. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine for compliance with requirements for conditions affecting installation and performance of HVAC casings. Verify that there is sufficient clearance for access and to install all fittings.
- B. Examine casing insulation materials and insulation before installation. Reject casings that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install casings and panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and manufacturer's written installation instructions.
- B. Apply sealant to joints, connections, and mountings.
- C. Field-cut openings for penetrations; insulate and seal in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- D. Seal all penetrations airtight.
- E. Support components rigidly with ties, braces, brackets, and anchors of types that will maintain housing shape and prevent buckling.
- F. Align casings accurately at connections, with 1/8-inch misalignment tolerance and with smooth interior surfaces.

3.3 CLEANING

- A. Comply with requirements for cleaning in Section 23 3113 "Metal Ducts."

END OF SECTION 23 3119.16

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SECTION 23 3300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Manual volume dampers.
2. Fire dampers.
3. Flange connectors.
4. Duct silencers.
5. Turning vanes.
6. Remote damper operators.
7. Duct-mounted access doors.
8. Flexible connectors.
9. Flexible ducts.

- B. Related Sections:

1. Division 25 Section "Integrated Automation Facility Controls" for motorized control dampers and damper actuators.
2. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

- A. Product Data: For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. Flexmaster U.S.A., Inc.
 - d. Greenheck.
 - e. McGill AirFlow LLC.
 - f. METALAIRE, Inc.
 - g. Nailor Industries Inc.
 - h. Pottorff.
 - i. Ruskin Company.
 - j. Trox USA Inc.
 - k. United Enertech.
 - l. Vent Products Company, Inc.
 - 2. Standard leakage rating, with linkage outside airstream.
 - 3. Suitable for horizontal or vertical applications.
 - 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch thick.
 - 5. Blade Axles: Galvanized steel.
 - 6. Bearings:
 - a. Oil-impregnated bronze or molded synthetic.

- b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

- 7. Tie Bars and Brackets: Galvanized steel.

2.3 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance Inc.; a division of Mestek, Inc.
 - 2. Cesco Products; a division of Mestek, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Pottorff.
 - 6. Ruskin Company.
 - 7. United Enertech.
 - 8. Vent Products Company, Inc.
- B. Type: Static; rated and labeled according to UL 555 by an NRTL.
- C. Fire Rating: 1-1/2 hours.
- D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - 1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
 - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.4 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Ductmate Industries, Inc.
 - 2. Nexus PDQ; Division of Shilco Holdings Inc.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.5 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Kinetics Noise Control.
 - 2. McGill AirFlow LLC.
 - 3. Ruskin.
 - 4. Vibro-Acoustics.
 - 5. Semco.
 - 6. Price-HVAC.
- B. General Requirements:
 - 1. Factory fabricated.
 - 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
 - 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Shape:
 - 1. Rectangular straight with splitters or baffles.
 - 2. Rectangular elbow with splitters or baffles.
 - 3. Rectangular transitional with splitters or baffles.
- D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.034 inch thick.
- E. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch- diameter perforations.
- F. Special Construction:
 - 1. Suitable for outdoor use.
- G. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- H. Principal Sound-Absorbing Mechanism:
 - 1. Dissipative type with fill material.
- I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Lock form and seal or continuously weld joints.
2. Reinforcement: Cross or trapeze angles for rigid suspension.

J. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.

K. Source Quality Control: Test according to ASTM E 477.

2.6 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.7 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Pottorff.
2. Ventfabrics, Inc.
3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Wall-Box Mounting: Recessed.

2.8 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
4. Flexmaster U.S.A., Inc.

5. Greenheck Fan Corporation.
 6. McGill AirFlow LLC.
 7. Nailor Industries Inc.
 8. Pottorff.
 9. Ruskin.
 10. Ventfabrics, Inc.
 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
- C. Rectangular Ductwork Applications:
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 24 Inches: Three hinges and two compression latches with outside and inside handles.

2.9 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Ductmate Industries, Inc.
 2. Duro Dyne Inc.
 3. Ventfabrics, Inc.
 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
1. Minimum Weight: 26 oz./sq. yd..
 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.

3. Service Temperature: Minus 40 to plus 200 deg F.
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd..
 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 3. Service Temperature: Minus 50 to plus 250 deg F.

2.10 FLEXIBLE DUCTS

- A. Insulated, Flexible Duct (Type F-1): UL 181, Class 1, acoustically rated, woven fiberglass fabric with flame resistant coated core supported by helically wound, spring-steel wire; fibrous-glass insulation (R-4.2); bi-directional reinforced metallized vapor-barrier film.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Themaflex Model M-KC or comparable product by the following:
 - a. Flexmaster U.S.A., Inc.
 2. Positive Pressure Rating: 16-inch wg positive for sizes 4 to 10 Inches, 10-inch wg positive for sizes 12 to 16 Inches.
 3. Maximum Air Velocity: 6000 fpm.
 4. Temperature Range: Minus 20 to plus 250 deg F.
 5. Insulation R-value: R-4.2
- B. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or nylon strap in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.
- B. Install duct accessories of galvanized-steel materials in galvanized-steel ducts.
- C. Install turning vanes in all square or rectangular divided flow branches and 90 degree elbows.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install fire dampers according to UL listing.

- G. Connect ducts to duct silencers rigidly.
 - 1. When elbows precede duct silencer by less than 3 duct widths (as measured in the elbow plane), splitters should be parallel to the plane of the elbow turn.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
- I. Access Door Minimum Sizes:
 - 1. Two-Hand or Inspection Access: 12 by 12 inches.
 - 2. Head and Shoulders Access: 20 by 16 inches.
 - 3. Body Access: 24 by 24 inches.
 - 4. For ducts less than 12 by 12 inches
- J. Install flexible connectors to connect ducts to equipment.
- K. Install flexible ducts as follows:
 - 1. Install flexible ducts at accessible concealed locations only.
 - 2. Install flexible ducts fully extended.
 - 3. Install flexible ducts in a direct line, without sags, twists, or turns.
 - 4. Connect diffusers to ducts directly or with maximum 36-inch lengths of flexible duct Type F-1, clamped or strapped in place. Flexible ducts are for alignment purposes only. Do not use flexible ducts to change directions.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
 - 3. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 3300

SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:

- 1. Ceiling-mounting ventilators.
- 2. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.9 COORDINATION

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

PART 2 - PRODUCTS

2.1 CEILING-MOUNTING VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Breidert Air Products.
 - 2. Broan Mfg. Co., Inc.
 - 3. Greenheck.
 - 4. Loren Cook Company.
 - 5. Penn Ventilation.
- B. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

2.2 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck.
 - 2. Loren Cook Company.
 - 3. Penn -Barry.

- B. Description: In-line, direct -driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

2.3 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Support suspended ceiling mounted units from structure using threaded steel rods and vibration isolators.
- C. Support suspended units from structure using threaded steel rods and elastomeric hangers. Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- D. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections with the assistance of a factory-authorized service representative and prepare test reports:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. 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.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. 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.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 10. Shut unit down and reconnect automatic temperature-control operators.
 - 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- C. Lubricate bearings.

END OF SECTION 23 3423

SECTION 23 3433.13 - COMMERCIAL AIR CURTAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section includes: Commercial air-curtain units.

1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, sound-power ratings, finishes, and accessories for each product indicated.
 - 1. Factory Installed Control Devices: Technical guides for factory installed control devices, including software/hardware inputs/outputs and sequences of operation.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, mounting details, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, factory control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Furnish one set of filters for each unit installed.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of air curtains through one source from a single manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the manufacturers specified.

1. Berner International.
2. Mars Air Systems.
3. Powered Aire Inc.

2.2 COMMERCIAL AIR-CURTAIN UNIT

- A. Housing:

1. Galvanized Steel: Galvanized steel with electrostatically applied, epoxy-enamel, powder-coat finish, in color selected by Architect.
2. Aluminum: Aluminum with electrostatically applied, epoxy-enamel, powder-coat finish, in color selected by Architect.
3. Discharge Nozzle: Integral to housing, containing adjustable air-directional vanes with 40-degree sweep front to back.

- B. Mounting Brackets: Galvanized steel, for wall or ceiling mounting.

- C. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

- D. Electric-Resistance Coils:

1. Coil Assembly: Comply with UL 1995.
2. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
3. Overtemperature Protection: Automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.
4. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:
 - a. Magnetic contactor.
 - b. Airflow-proving switch.

- E. Filters:

1. Washable Panel Filters: Removable, baffle-type filters with spring-loaded fastening; with minimum 0.0781-inch- thick, filter frame.

F. Controls:

1. Remote Thermostat: Contacts for field provided thermostat.
2. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.
3. Interface Requirements for HVAC Instrumentation and Control System:
 - a. Control sequence of operations are indicated on control drawings.
 - 1) Provide BACnet compatible interface for central HVAC control workstation for the following:
 - a) Analog Read/Write: Cool Down Delay
 - b) Analog Read/Write: Fan Speed
 - c) Analog Read/Write: Inlet Temperature Setpoint
 - d) Analog Read/Write: Time Delay
 - e) Analog Read: Inlet Temperature
 - f) Binary Read/Write: Fan On/Off
 - g) Binary Read/Write: Call for Heat On/Off
 - h) Binary Read/Write: Heater On/Off
 - i) Binary Read: Door Status
 - j) Multistate Read/Write: Operating Mode

G. Accessories:

1. Wiring for physical interconnection operation of units.

2.3 SOURCE QUALITY CONTROL

- A. AMCA Certification for Fan Aerodynamic Performance Rating: Test, rate, and label, air curtain units in accordance with AMCA 211.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air curtains with clearance for equipment service and maintenance.
- B. Comply with requirements for hangers and supports specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- C. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections with the assistance of a factory-authorized service representative and prepare test reports:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial air curtains. Coordinate with general contractor for general demolition requirements and procedures.

END OF SECTION 23 3433.13

SECTION 23 3600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Shutoff, single duct air terminal units.
 - 2. Fan-powered air terminal units.

1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, sound-power ratings, finishes, and accessories for each product indicated.
 - 1. Factory Installed Control Devices: Technical guides for factory installed control devices, including software/hardware inputs/outputs and sequences of operation.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, mounting details, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, factory control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers:
 - 1. Anemostat; a Mestek Company.
 - 2. Johnson Controls
 - 3. Krueger.
 - 4. Nailor Industries of Texas Inc.
 - 5. Price Industries.
 - 6. Titus.
 - 7. Trane.
 - 8. Tuttle & Bailey.
- B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- C. Casing: Steel or aluminum.
 - 1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 2. Air Outlet: S-slip and drive connections.
 - 3. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
 - 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Velocity Sensors: Multipoint array with velocity sensors in air inlet.
- E. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
 - 1. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
- F. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
- G. Electric Heating Coil: Slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:
 1. Primary and secondary overtemperature protection.
 2. Nickel chrome 80/20 heating elements.
 3. Airflow switch.
- H. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
 1. Disconnect Switch: Factory-mounted with door interlock and overcurrent protection device.
- I. Control equipment and sequence of operation are specified in Division 25 Section "Integrated Automation Facility Controls."

2.3 FAN-POWERED AIR TERMINAL UNITS

- A. Manufacturers:
 1. AirFixture.
- B. Description: Low-profile unit casing with fan and control components inside a protective metal shroud.
- C. Casing: Galvanized steel.
 1. Integral grille.
 2. Access: Removable panels on top of casing, for access to parts requiring service, adjustment, or maintenance.
 3. Fan: Forward-curved centrifugal.
- D. Electric Heating Coil: Sheathed coil design with integral control box factory wired and installed. Include the following features:
 1. Primary and secondary overtemperature protection.
 2. Nickel chrome 80/20 heating elements.
- E. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
 1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 2. Wiring Terminations: Fan and controls to terminal strip. Verify terminal lugs match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized in accordance with NFPA 70.
 3. Disconnect Switch: Factory-mounted with overcurrent protection device.

- F. Control equipment and sequence of operation are specified in Division 25 Section "Integrated Automation Facility Controls."

2.4 MOTORS

- A. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- B. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."
- C. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- E. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Verify that the inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

3.3 STARTUP SERVICE

- A. Perform the following field tests and inspections with the assistance of a factory-authorized service representative and prepare test reports:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties.

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- B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 3600

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SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section includes diffusers, registers, and grilles.
- B. Related Sections:
 - 1. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Grilles, Registers and Diffusers:
 - a. Krueger.
 - b. Price.
 - c. Tuttle and Bailey.
 - d. Titus.
 - e. Nailor.

2.2 DIFFUSERS

- A. General: Provide manufacturer's standard diffusers where shown; of size, shape, capacity and type as listed on diffuser schedule, with accessories and finishes as indicated.
 - 1. Diffuser Mountings
 - a. Surface: Diffuser housing at duct, wall or ceiling surface with gasketed perimeter flange.

- b. Lay-In: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.

2.3 GRILLES AND REGISTERS

- A. General: Provide manufacturer's standard grilles and registers where shown; of size, shape, capacity and type as listed on schedule, with accessories and finishes as indicated.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 DIFFUSER, REGISTER, AND GRILLE INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts.
- D. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 3713

SECTION 23 7413 - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:
 - 1. Heat-pump refrigeration components.
 - 2. Hot-gas reheat.
 - 3. Gas furnace.
 - 4. Economizer outdoor- and return-air damper section.
 - 5. Integral, space temperature controls.
 - 6. Curbs.

1.3 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. ECM: Electrically commutated motor.
- C. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
- D. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
- E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and size of unit indicated. Include rated capacities, dimensions, required clearances, operating characteristics, furnished specialties, and accessories.
 - 1. Factory Installed Control Devices: Technical guides for factory installed control devices, including software/hardware inputs/outputs and sequences of operation.

- 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

- 1. Filters: One set of filters for each unit.

1.8 QUALITY ASSURANCE

- A. ARI Compliance:

- 1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
 - 2. Comply with ARI 270 for testing and rating sound performance for RTUs.

- B. ASHRAE Compliance:

- 1. Comply with ASHRAE 15 for refrigeration system safety.
 - 2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
 - 3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

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

- D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

- E. 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. AAON, Inc.
2. Trane Horizon.
3. Valent; A division of Greenheck.

2.2 CASING

- A. General Fabrication Requirements for Casings: Formed and reinforced insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
- C. Inner Casing Fabrication Requirements:
1. Inside Casing: Galvanized steel.
- D. Condensate Drain Pans: Non-corrosive material complying with ASHRAE 62.1.
1. Drain Connections: Threaded nipple.
- E. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.3 FANS

- A. Plenum Fans:
1. Fan Mounting: Mount fan and motor on a structural steel frame mounted on manufacturer's standard restrained vibration isolation mounting devices sized to eliminate fan vibration and noise.
 2. Fan Wheels: Single-width, single-inlet, plenum fan wheel.
 3. Drives: Direct drive.
 4. Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.
- B. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.
- C. Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 COILS

A. Condenser Coils:

1. Condenser coils shall use Micro-Channel coil technology. Coil shall have a series of flat tubes containing a series of multiple, parallel flow micro-channels layered between the refrigerant manifolds. Micro-channel coils shall consist of a two-pass arrangement. Coils shall be factory leak and pressure tested.

B. Supply-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Coil Split: Interlaced.

C. Hot-Gas Reheat Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.

2.5 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant: A2L Refrigerant.
2. A2L refrigerant leakage detection control device with alarm.
3. Expansion valve with replaceable thermostatic element.
4. Refrigerant filter/dryer.
5. Manual-reset high-pressure safety switch.
6. Automatic-reset low-pressure safety switch.
7. Minimum off-time relay.
8. Automatic-reset compressor motor thermal overload.
9. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.
10. Defrost cycle to prevent frost accumulation on condenser coil.

2.6 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

2.7 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

- B. Burners: Stainless steel.
 - 1. Fuel: Liquefied-Petroleum Gas Furnace.
 - 2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
- C. Heat-Exchanger and Drain Pan: Stainless steel.
- D. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
- E. Safety Controls:
 - 1. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.8 DAMPERS

- A. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
 - 1. Damper Motor: Modulating with adjustable minimum position.
 - 2. Relief-Air Damper: Barometric or motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

2.9 ELECTRICAL POWER CONNECTION

- A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

- A. Interface Requirements for HVAC Instrumentation and Control System:
 - 1. Control sequence of operations are indicated on control drawings.
 - 2. Provide BACnet compatible interface for central HVAC control workstation for the following:
 - a. Analog Read/Write: Building Static Pressure Setpoint
 - b. Analog Read/Write: Cooling Coil Discharge Air Setpoint
 - c. Analog Read/Write: Discharge Air Cooling Setpoint
 - d. Analog Read/Write: Discharge Air Heating Setpoint
 - e. Analog Read/Write: Duct Static Pressure Setpoint
 - f. Analog Read/Write: Economizer Enable
 - g. Analog Read/Write: Economizer Minimum Position
 - h. Analog Read/Write: Exhaust/Return Fan Speed Setpoint
 - i. Analog Read/Write: Morning Warm-Up Return Air Temperature
 - j. Analog Read/Write: Occupied Cooling Setpoint
 - k. Analog Read/Write: Occupied Heating Setpoint
 - l. Analog Read/Write: Outdoor Air Humidity
 - m. Analog Read/Write: Outdoor Air Minimum Position

- n. Analog Read/Write: Outdoor Air Temperature
- o. Analog Read/Write: Outdoor Airflow Setpoint
- p. Analog Read/Write: Space CO2
- q. Analog Read/Write: Space CO2 Setpoint
- r. Analog Read/Write: Space Relative Humidity
- s. Analog Read/Write: Space Relative Humidity Setpoint
- t. Analog Read/Write: Space Temperature
- u. Analog Read/Write: Supply Fan Speed Setpoint
- v. Analog Read/Write: Unoccupied Cooling Setpoint
- w. Analog Read/Write: Unoccupied Heating Setpoint
- x. Analog Read: Building Static Pressure
- y. Analog Read: Cooling Capacity
- z. Analog Read: Cooling Coil Discharge Air Temperature
- aa. Analog Read: Discharge Air Temperature
- bb. Analog Read: Duct Static Pressure
- cc. Analog Read: Exhaust/Return Fan Speed
- dd. Analog Read: Gas Heating Capacity
- ee. Analog Read: Heating Capacity
- ff. Analog Read: Hot Gas Reheat Capacity
- gg. Analog Read: Outdoor Air Damper Position
- hh. Analog Read: Outdoor Airflow
- ii. Analog Read: Return Air Humidity
- jj. Analog Read: Return Air Temperature
- kk. Analog Read: Supply Airflow
- ll. Analog Read: Supply Fan Speed
- mm. Binary Read: A2L Refrigerant Leak Status
- nn. Binary Read: Cooling Status
- oo. Binary Read: Economizer Status
- pp. Binary Read: Emergency Heat Status
- qq. Binary Read: Heat Pump Auxiliary Heat Status
- rr. Binary Read: Heating Status
- ss. Multistate Read/Write: Emergency Override Command
- tt. Multistate Read/Write: Heat/Cool Mode
- uu. Multistate Read/Write: Occupancy
- vv. Multistate Read: Unit Status

2.11 CURBS

- A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C 1071, Type I or II.
 - b. Thickness: 1-1/2 inches.
 - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C 916, Type I.

- b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
- c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
- d. Liner Adhesive: Comply with ASTM C 916, Type I.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting: Install RTUs on concrete base using elastomeric pads. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
- B. Curb: Install on concrete base, level and secure. Seal RTUs to plenum curbs according to curb manufacturer's instructions. Secure RTUs to upper curb rail, and secure curb base to concrete base with anchor bolts.

3.3 CONNECTIONS

- A. Install condensate drain, minimum connection size, with trap.
- B. Install piping adjacent to RTUs to allow service and maintenance.
 - 1. Gas Piping: Comply with applicable requirements in Division 23 Section "Facility Liquefied-Petroleum Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- C. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Connect supply ducts with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Tests and Inspections:
 - 1. Perform field tests and inspections including air leakage testing of duct and RTU connections to curbs in accordance with SMACNA's "HVAC Air Duct Leakage Test Manual."
 - a. Conduct testing at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - b. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirement for leakage classification of ducts connected to plenums or casings.
 - c. Disassemble, reassemble, and seal RTUs to curbs to accommodate leakage testing and for compliance with test requirements.
- C. Perform the following field tests and inspections with the assistance of a factory-authorized service representative and prepare test reports:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Inspect for visible damage to unit casing.
 - 3. Inspect for visible damage to furnace combustion chamber.
 - 4. Inspect for visible damage to compressor, coils, and fans.
 - 5. Inspect internal insulation.
 - 6. Verify that labels are clearly visible.
 - 7. Verify that clearances have been provided for servicing.
 - 8. Verify that controls are connected and operable.
 - 9. Verify that filters are installed.
 - 10. Clean condenser coil and inspect for construction debris.
 - 11. Clean furnace flue and inspect for construction debris.
 - 12. Connect and purge gas line.
 - 13. Remove packing from vibration isolators.
 - 14. Inspect operation of barometric relief dampers.
 - 15. Verify lubrication on fan and motor bearings.
 - 16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 17. Adjust fan belts to proper alignment and tension.
 - 18. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.
 - c. Complete startup sheets and attach copy with Contractor's startup report.
 - 19. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 20. Operate unit for an initial period as recommended or required by manufacturer.
 - 21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
 - a. Measure gas pressure on manifold.
 - b. Inspect operation of power vents.
 - c. Measure combustion-air temperature at inlet to combustion chamber.

- d. Measure flue-gas temperature at furnace discharge.
 - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
- 22. Calibrate thermostats.
- 23. Adjust and inspect high-temperature limits.
- 24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
- 25. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
- 26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
- 27. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
- 28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - a. High-temperature limit on gas-fired heat exchanger.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and firestat alarms.
- 29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.
- D. Remove and replace malfunctioning units and retest as specified above.

3.5 CLEANING AND ADJUSTING

- A. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan coil units. Coordinate with general contractor for additional demonstration and training requirements.

END OF SECTION 23 7413

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SECTION 23 8126 – SPLIT SYSTEM AIR CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.3 ACTION SUBMITTALS

- A. For each type and size of split system air conditioner indicated. Include rated capacities, dimensions, required clearances, operating characteristics, furnished specialties, and accessories.
 - 1. Factory Installed Control Devices: Technical guides for factory installed control devices, including software/hardware inputs/outputs and sequences of operation.
- 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, factory control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set of filters for each unit.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

- A. Coordinate size, location, and connection details with equipment supports, and penetrations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Enviromaster International.
 - 2. Carrier Air Conditioning; Div. of Carrier Corporation.
 - 3. Daikin/McQuay.
 - 4. LG Electronics.
 - 5. Mitsubishi Electronics America, Inc.; HVAC Division.
 - 6. Sanyo Fisher (U.S.A.) Corp.
 - 7. Trane.
 - 8. JCI/York.

2.2 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

- A. Cabinet: Removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
- C. Fan: Direct drive, centrifugal fan.
- D. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- E. Filters: Permanent, cleanable.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

- A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
- D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.
- E. Fan: Propeller type, directly connected to motor.
- F. Motor: Permanently lubricated, with integral thermal-overload protection.

2.4 ACCESSORIES

- A. Controls: MSTP interface compatible with building automation system.
- B. Thermostat: Wall mounted hard wired, functioning to remotely control compressor and evaporator fan, with the following features:
 - 1. Compressor time delay.
 - 2. 24-hour time control of system stop and start.
 - 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 - 4. Fan-speed selection, including auto setting.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

- D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP SERVICE

- A. Perform the following field tests and inspections with the assistance of a factory-authorized service representative and prepare test reports:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Coordinate with general contractor for additional demonstration and training requirements.

END OF SECTION 23 8126

SECTION 23 8239 - UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Cabinet unit heaters with centrifugal fans and electric-resistance heating coils.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and size of unit heater indicated. Include rated capacities, dimensions, required clearances, operating characteristics, furnished specialties, and accessories.
 - 1. Factory Installed Control Devices: Technical guides for factory installed control devices, including software/hardware inputs/outputs and sequences of operation.
- 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, factory control wiring, and control wiring terminals for field installed controls.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Cabinet Unit Heater Filters: Furnish one spare filter for each filter installed.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of unit heaters through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 1. Berko Electric Heating; a division of Marley Engineered Products.
 - 2. Daikin/McQuay.
 - 3. Indeco.
 - 4. Markel Products; a division of TPI Corporation.
 - 5. Marley Electric Heating; a division of Marley Engineered Products.
 - 6. QMark Electric Heating; a division of Marley Engineered Products.
 - 7. Trane.

2.2 ELECTRIC CABINET UNIT HEATERS

- A. Description: A factory-assembled and -tested unit complying with ARI 440.
 - 1. Comply with UL 2021.
- B. Coil Section Insulation: Surfaces exposed to airstream shall be coated to prevent erosion of insulation.
 - 1. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
- C. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect. Include removable panels with tamperproof fasteners and the following:
- D. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
- E. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- F. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
- G. Control devices and operational sequence are specified in Division 25 Sections.
- H. Electrical Connection: Factory wire for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cabinet unit heaters to comply with NFPA 90A.
- B. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- C. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment."
- D. Install new filters in each cabinet heater within two weeks of Substantial Completion.

3.2 CONNECTIONS

- A. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections with the assistance of a factory-authorized service representative and prepare test reports:
 1. Perform installation and startup checks according to manufacturer's written instructions.
 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 4. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit heaters. Coordinate with general contractor for additional demonstration and training requirements.

END OF SECTION 23 8239

SECTION 25 5000 – INTEGRATED AUTOMATION FACILITY CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 DEFINITIONS

- A. BACnet: BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
- B. DDC: Direct digital control.
- C. I/O: Input/output.
- D. MS/TP: Master slave/token passing.
- E. PC: Personal computer.
- F. PID: Proportional plus integral plus derivative.
- G. RTD: Resistance temperature detector.

1.3 SUMMARY

- A. Work shall include furnishing all labor, materials, equipment, and service necessary for a complete and operating Building Management System (BMS), utilizing direct digital controls. The BMS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet. This shall include HVAC control, electrical, gas, energy management, alarm monitoring, fire-life safety system monitoring, and all trending, reporting and maintenance management functions related to normal building operations all as indicated.
 - 1. Project control drawings are diagrammatic only. All labor, material, equipment and software not specifically referred to herein or on the plans, required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.
- B. Work shall include but not limited to providing controls and instrumentation in accordance with equipment sequence of operations and their point lists. Point lists shall be a guide to the points required for control system. Final points required shall be determined by sequence of operation requirements.
- C. Work required in this section shall include the complete Building Management System (BMS) including all controllers Interoperable BACnet Controllers (IBC), control devices, control panels, controller programming, controller programming software, controller input/output wiring, power wiring, interlock and safety wiring, graphical user interface, Graphical User Interface (GUI), Graphical Development Tool (GDT), Network Area

Controller(s) (NAC), server software, controller software and programming of the NAC and server, development of all graphical screens, setup of schedules, logs and alarms, global server software control applications, system integration and coordination of the NAC and server software to the Wide Area Network.

1.4 PROCUREMENT FOR INTEGRATED AUTOMATION FACILITY CONTROLS

- A. The proposal shall include all of the information outlined and samples requested herein and shall be included as a single PDF file. Facsimiles and any other file types other than PDFs, will not be accepted. Provide the following:
1. Letter of introduction & company history.
 - a. Insert letter of introduction with company philosophy.
 - b. Insert company history summary (include years incorporated minimum of 3 years).
 - c. Control system manufacturer and product line represented.
 2. Professional References: Provide a minimum of (3) professional references pertaining to this scope type, including:
 - a. Project(s) Name
 - b. Project Location(s)
 - c. Owner or Owner's Representative Contact Info
 3. Relevant instrumentation and control for HVAC experience: Provide a minimum of (5) relevant instrumentation and control for HVAC experience projects pertaining to this scope type, including:
 - a. Project Name
 - b. Project Location
 - c. Job Description
 - d. Mechanical System Types
 - e. Construction Management Firm or General Contractor
 - f. Building Square Footage
 - g. Total Construction Cost
 - h. Instrumentation and Control for HVAC Fee
 4. Sample Instrumentation and Control for HVAC graphics: Provide samples of control graphics pertaining to this scope type, including:
 - a. Color graphics of systems called out on temperature control drawings.
 - b. Color graphics of floor plans showing labeled equipment, sensor locations, and zones.
 - c. Color graphics of building main dashboard.

1.5 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 25 5xxx – Integrated Automation
1. Integrated Automation Facility Controls
 - a. Wells, sockets and other inline hardware for water sensors (temperature, pressure, flow).
 - b. Airflow Measuring Stations
 - c. In-Line Meters (Gas, Water, Power)
 - d. Control Dampers

1.6 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 22 3xxx – Plumbing Equipment
 - 1. Manufacture furnished controls and sensors for field installation.
- B. Section 23 3xxx – HVAC Air Distribution
 - 1. Manufacture furnished controls and sensors for field installation.
- C. Section 23 7xxx – Central HVAC Equipment
 - 1. Manufacture furnished controls and sensors for field installation.
- D. Section 23 8xxx – Decentralized HVAC Equipment
 - 1. Manufacture furnished controls and sensors for field installation.

1.7 PRODUCTS NOT FURNISHED OR INSTALLED UNDER THIS SECTION, BUT INTEGRATED WITH THE WORK OF THIS SECTION

- A. Section 22 1xxx – Plumbing Piping and Pumps
 - 1. Domestic Water Pumps
- B. Section 22 3xxx – Plumbing Equipment
 - 1. Electric Domestic Water Heaters
- C. Section 26 0xxx – Electrical
 - 1. Electrical Energy Metering.
 - 2. Lighting Control Devices.
- D. Section 28 3xxx – Electronic Detection and Alarm
 - 1. Fire Detection and Alarm.
- E. Section 23 3xxx – HVAC Air Distribution
 - 1. HVAC Power Ventilators.
 - 2. Commercial Air Curtains.
 - 3. Air Terminal Units.
- F. Section 23 7xxx – Central HVAC Equipment
 - 1. Packaged, Outdoor, Central-Station Air-Handling Units
- G. Section 23 8xxx – Decentralized HVAC Equipment
 - 1. Split-System Air-Conditioners.

2. Unit Heaters.

1.8 COORDINATION

- A. Coordinate location of zone sensors, humidistats, and other exposed control sensors with plans and room details before installation. Field coordinate location of zone sensors, humidistats, and other exposed control sensors during installation with all trades.
- B. Coordinate equipment with Section 22 1xxx – “Plumbing Piping and Pumps”. Equipment manufacture shall furnish equipment specified to have factory installed controls, with an interface to the control and monitoring points indicated in temperature control drawings. These specified points shall be the minimum acceptable interface to the vendor supplied equipment. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA (b) BACnet (c) Modbus.
- C. Coordinate equipment with Section 22 3xxx – “Domestic Water Heating Equipment”. Equipment manufacture shall furnish equipment specified to have factory installed controls, with an interface to the control and monitoring points indicated in temperature control drawings. These specified points shall be the minimum acceptable interface to the vendor supplied equipment. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA (b) BACnet (c) Modbus.
- D. Coordinate equipment with Section 23 3xxx – “HVAC Air Distribution”. Equipment manufacture shall furnish equipment specified to have factory installed controls, with an interface to the control and monitoring points indicated in temperature control drawings. These specified points shall be the minimum acceptable interface to the vendor supplied equipment. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA (b) BACnet (c) Modbus.
- E. Coordinate equipment with Section 23 7xxx – “Central HVAC Equipment”. Equipment manufacture shall furnish equipment specified to have factory installed controls, with an interface to the control and monitoring points indicated in temperature control drawings. These specified points shall be the minimum acceptable interface to the vendor supplied equipment. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA (b) BACnet (c) Modbus.
- F. Coordinate equipment with Section 23 8xxx – “Decentralized HVAC Equipment”. Equipment manufacture shall furnish equipment specified to have factory installed controls, with an interface to the control and monitoring points indicated in temperature control drawings. These specified points shall be the minimum acceptable interface to the vendor supplied equipment. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA (b) BACnet (c) Modbus.
- G. Coordinate equipment with Section 26 0xxx – “Electrical.” Equipment manufacture shall furnish equipment specified to have factory installed controls, with an interface to the control and monitoring points indicated in temperature control drawings. These specified points shall be the minimum acceptable interface to the vendor supplied equipment. The connection to these points shall be by one of the following methods: (a) Hardwired connection such as relay, 0-10VDC, or 4-20mA (b) BACnet (c) Modbus.
- H. Coordinate equipment with Section 28 3xxx – “Electronic Detection and Alarm” to achieve compatibility with equipment that interfaces with that system.

- I. Work required in this section shall include providing all electrical work required for this section. The system shall include all interconnecting wiring and conduit as required for a fully operational system as specified. Wiring shall be installed as per local codes or Division 26 whichever is more stringent.
 1. Power supply wiring and conduit from power source to power connection on DDC controls and DDC control panels.
 - a. Line voltage wiring shall utilize methods and materials complying with the requirements of the Electrical Specifications, local building code, and NEC.
 2. Control wiring and conduit between field-installed controls, indicating devices, and control panels.
 - a. Low voltage wiring shall use methods and materials complying with the requirements of the Electrical Specifications, local building code and NEC. Plenum rated cable is acceptable where concealed and accessible.

1.9 RELATED SECTIONS

- A. The following Sections contain requirements that relate to this Section:
 1. Division 01 "General Commissioning Requirements" for commissioning of Instrumentation and Control for HVAC.
 2. Division 23 "Common Work Results for HVAC" for requirements that relate to this Section.
 3. Division 23 "Testing, Adjusting, and Balancing for HVAC" for requirements that relate to this Section.
 4. Division 23 "Commissioning of HVAC" for commissioning of Instrumentation and Control of HVAC.

1.10 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
- 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. DDC System Hardware:
 - a. Schematic diagrams for control units with termination numbers.
 - b. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors, required network data ports by owner, and wiring between operator workstation and control unit locations.
 2. Controlled Systems:
 - a. Preliminary ladder wiring diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Written description of sequence of operation including schematic diagram.
 - c. Points list including bill of materials.
- C. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations. Meet with facility and maintenance personnel and owner's representative, to review control system software graphics, prior to submittal.
 1. Color graphics for each system with a sequence of operation.

2. Color graphics of floor plans showing labeled equipment, sensor locations, and zones.
3. Color graphics of building main dashboard, indicating the following:
 - a. Outdoor air conditions and building pressure.
 - b. Links to hydronics systems, power systems, schedules, alarms, trends, and floor plans with equipment locations.
 - c. Setpoint and operating point of each area, global equipment status indications, and occupancy statuses.
 - d. Performance of power monitoring systems and 12 month trends
 - e. Performance of natural-gas monitoring and 12 month trends
 - f. Domestic hot water system status indications.
 - g. Fire alarm system status indication.

1.11 INFORMATIONAL SUBMITTALS

- A. Control system checkout and testing reports.

1.12 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency operation, and maintenance manuals. Coordinate with general contractor "Operation and Maintenance Data" requirements and include the following:
 1. Maintenance instructions and lists of spare parts for each type of control device.
 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 3. Updated shop drawings submittals based on as-built conditions.
 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 5. Calibration records and list of set points.
- B. Software and Firmware Operational Documentation: Include the following:
 1. Software operating and upgrade manuals.
 2. Device address list.
 3. Printout of custom software application screens.
 4. Software license required by and installed for DDC workstations and control systems.

1.13 CODES AND APPROVALS

- A. The complete BMS installation shall be in strict compliance to the national, state and local mechanical and electrical codes and the electrical section of these specifications. All devices shall be UL or FM listed and labeled for the specific use, application and environment to which they are applied.
- B. The system shall comply with NFPA 90A Air Conditioning and 90B Warm Air Heating, Air conditioning.
- C. 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.
- D. All electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.

1.14 WARRANTY

- A. Warrant labor and materials for specified control system free from defects for a period of 24 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
- B. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
- C. If the commissioning authority determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the commissioning authority will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
- D. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.

1.15 QUALITY ASSURANCE

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

1.16 SOFTWARE LICENSE AGREEMENT

- A. Software licensing for the NAC and server software shall give the Owner the capability to control their system and determine which contractors can bid and engineer their system.
- B. It shall be possible to insure the Owner can prevent unauthorized partners from accessing the system for engineering changes.
- C. Software licensing shall have the freedom to individually manage authorized parties and independent parties.
- D. The Owner shall accept the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

1.17 OWNERSHIP OF PROPRIETARY MATERIAL

- A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:
 - 1. Graphics

2. Record Drawings
3. Database
4. Application Programming Code
5. Documentation

1.18 ADDED POINT AND MEMORY CAPACITY

- A. The BMS software/firmware provided shall have the capacity for an unlimited number of NACs. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.
- B. Total system point capacity shall have the capacity for an unlimited number of future points. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.
- C. Supervising software shall allow unlimited expansion. Supervising software that is limited to the number of network area controllers is not acceptable

1.19 TESTING AND BALANCING

- A. If proper sequencing or system functions cannot be achieved with the controls, as installed, and additional controls are required, the required additional controls shall be added at the expense of the Controls provider.

1.20 DELIVERY, STORAGE, AND PROTECTION

- A. Store equipment and materials inside and protected from weather.
- B. System Software: Update to latest version of software/firmware at Project completion and through warranty period.

1.21 COORDINATION

- A. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM SUPPLIERS

- A. The control system supplier shall have a local office within a 75 mile radius of the job site, staffed with factory trained engineers fully capable of providing instruction, routine maintenance and 24-hour emergency service on all system components. The control system supplier shall have a three year experience record

in the design and installation of computerized building systems similar in scope and performance to that specified herein.

B. Available control system suppliers, manufacturers, and product lines:

* If supplier is shown with asterisk, supplier shall be considered as base bid.

Supplier	Manufacturer	Software Platform
Any	Automated Logic	WebCTRL
Any	Delta Controls	Niagra 4
Any	Distech Controls	Niagra 4
Any	Honeywell	Niagra 4
Any	Johnson Controls Facility Explorer	Niagra 4
Any	Schneider Electric	Niagra 4
Any	Trane	Trane
Any	Vykon	Niagra 4

1. The controls contractor shall use only controller software, and custom application programming language, for the corresponding manufacturer and product line.
2. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on high-speed, peer-to-peer network and programmed to control mechanical systems. An operator workstation and web-based interface, permits access with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

D. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner's local area network, and over the Internet. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends.

E. Additional Control System Supplier Responsibilities:

1. Provide comments on and stamp/review as a consultant, manufacture submittals specified in the Section "Coordination" of this specification prior to the Architect/Engineer, to coordinate details of the interface between these products and the DDC network.
2. Meet with facility and maintenance personnel and owner's representative, to review control system software graphics, prior to submittal.
3. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation described in temperature control drawings.
4. Coordinate and resolve an incompatibility issues that arise between control products provided under this section and those under other sections or divisions of this specifications.

2.2 MATERIALS

- A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site. Spare parts shall be available for at least five years after completion of this contract.

2.3 GENERAL

- A. The Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers, Network Area Controllers, server software server, graphical user interface software, Web Browser Clients, operator work stations, network devices and other devices as specified herein.

2.4 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

- A. The requirement of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate SNMP, BACnet IP, BACnet MSTP, Modbus TCP/IP or Modbus RTU communication protocols in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135, BACnet to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet. For each Modbus device supplier must provide a Registry of data points available on the system.
- C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
- D. The supplied system must incorporate the ability to access all data using standard web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. The installed system shall provide secure password access to all features, functions and data contained in the overall BMS. Secure Socket Layer (SSL) encryption shall be an available option for remote access.
- F. The installed system must be totally scalable to allow for future expansion with the addition of controllers and/or input/output devices. It shall not be necessary to remove equipment supplied under this contract to expand the system.
- G. The failure of any single component or network shall not interrupt the control functions of non-affected devices. A single network failure shall only affect shared communications or shared data; individual application controllers and network controllers shall continue normal operation minus only the data from a remote device from the affected network. Automatic default values for all network transported data shall be provided to allow continued operation until the network is restored.

- H. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
 - 1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
 - 2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.5 NETWORK AREA CONTROLLER (NAC)

- A. The controls Installer shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices.
- B. The Network Area Controller (NAC) shall provide the interface between the ILC, IBC and the Network server software, and provide global supervisory control functions over the control devices connected to the BMS. It shall be capable of executing application control programs to provide:
 - 1. Calendar functions
 - 2. Scheduling
 - 3. Trending
 - 4. Alarm monitoring and routing
 - 5. Time synchronization
 - 6. Integration of Modbus controller data and BACnet controller data
- C. The Network Area Controller must provide the following hardware features as a minimum:
 - 1. Two Isolated Ethernet Ports – 10/100 Mbps
 - 2. One RS-232 port
 - 3. One RS-485 port
 - 4. Battery Backup
 - 5. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 10 gigabyte storage capacity)
 - 6. The NAC must be capable of operation over a temperature range of 32 to 130 deg F
 - 7. The NAC must be capable of withstanding storage temperatures of between 32 to 158 deg F
 - 8. The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing
- D. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 10 simultaneous users.
- E. Event Alarm Notification and actions
 - 1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
 - 2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
 - 3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
 - a. To alarm
 - b. Return to normal

- c. To fault
- 4. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
- 5. Provide timed (schedule) routing of alarms by class, object, group, or node.
- 6. Provide alarm generation from binary object "runtime" and for event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- 7. Control equipment and network failures shall be treated as alarms and annunciated.
- 8. Alarms shall be annunciated in any of the following manners as defined by the user:
 - a. Screen message text
 - b. Text or email of the complete alarm message to multiple recipients. Provide the ability to route and send alarms based on:
 - 1) Day of week
 - 2) Time of day
 - 3) Recipient
- 9. Graphic with flashing alarm object(s)
- 10. Printed message, routed directly to a dedicated alarm printer
- 11. The following shall be recorded by the NAC for each alarm (at a minimum):
 - a. Time and date
 - b. Location (building, floor, zone, office number, etc.)
 - c. Equipment (air handler #, access way, etc.)
 - d. Acknowledge time, date, and user who issued acknowledgement.
 - e. Number of occurrences since last acknowledgement.
- 12. Alarm actions may be initiated by user defined programmable objects created for that purpose.
- 13. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
- 14. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.
- 15. Provide a "query" feature to allow review of specific alarms by user defined parameters.
- 16. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- 17. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

F. Data Collection and Storage

- 1. The NAC shall have the ability to collect data for any object and store this data for future use.
- 2. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
- 3. Designating the log as interval or deviation.
- 4. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
- 5. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
- 6. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
- 7. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

8. All log data shall be stored in a relational database and the data shall be accessed from a standard Web Browser.
9. All log data, when accessed from the Network server software (NS), shall be capable of being manipulated using standard SQL statements.
10. All log data shall be available to the user in the following data formats:
 - a. HTML
 - b. XML
 - c. Plain Text
 - d. Comma or tab separated values
11. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
12. The NAC shall have the ability to archive its log data to Network server software on the network. Provide the ability to configure the following archiving properties, at a minimum:
 - a. Archive on time of day
 - b. Archive on user-defined number of data stores in the log (buffer size)
 - c. Archive when log has reached it's user-defined capacity of data stores
 - d. Provide ability to clear logs once archived

G. Audit Logs

1. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive the log based on time to the Network server software. For each log entry, provide the following data:
 - a. Time and date
 - b. User ID
 - c. Change or activity: i.e., Change set-point, add or delete objects, commands, etc.

H. Database Back-Up and Storage

1. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
2. Copies of the current database and, at the most recently saved database shall be stored on the Network server software. The age of the most recently saved database is dependent on the user-defined database save interval.
3. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2.6 INTEROPERABLE BACnet CONTROLLER (IBC)

- A. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the ANSI/ASHRAE Standard 135. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to the ANSI/ASHRAE Standard 135, to Owner.
- B. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps or via the RS485 connection at a baud rate of not less than 38 kbps.
- C. The IBC Sensor shall connect directly to the IBC and shall not utilize any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive.

The IBC Sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.

- D. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- E. The controls Installer shall provide documentation for each device, with the following information at a minimum:
 - 1. BACnet Device; MAC address, name, type and instance number
 - 2. BACnet Objects; name, type and instance number
- F. Ensure that the proper BACnet objects are provided in each IBC, as required by the point charts.

2.7 NETWORKS

- A. The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting TCP/IP, BACnet IP, Modbus, Java, XML, and HTTP for maximum flexibility for integration of building data with enterprise information systems
- B. Local area network minimum physical and media access requirements:
 - 1. Ethernet; IEEE standard 802.3
 - 2. Cable; 10 Base-T, UTP-8 wire, category 5E or 6
 - 3. Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps

2.8 NETWORK ACCESS

- A. Owners WAN / LAN Access: Controls Installer must adhere to Owner's policy and requirements to obtain Owner's WAN access.

2.9 GRAPHICAL USER INTERFACE (GUI)

- A. The graphical component of the BMS is of critical importance and should consider the following descriptions and graphic representations to be the minimum acceptable. Enhanced graphics shall include detailed 2-dimensional building site and floor plan graphics, 3-dimensional equipment graphics with fan, damper and valve animations providing operators an aid to comprehending complex system operation. Every graphic page shall contain a tabular and cascading menu navigational structure, established in an HTML frame based format to allow immediate "one-click" access to other building systems without the need to back up through the navigational tree.
- B. Navigation is done through the use of an HTML-based menu bar. The contents of the menu bar shall be customized to match the specific requirements of each building, while retaining the same general categories for consistency and familiarity.

1. The menu bar shall employ cascading menus. With this navigation concept, the operator shall not be more than two mouse button operations from any view. Some examples of the operator screens follow.
 2. Displays shall provide real-time information with visual display of alarm condition by change of color and/or flashing text/color background.
 3. Displays can be viewed from a non-proprietary, commercial Web Browser.
 4. Points that have been defined as data-writes, either as a digital (on/off) or analog (change value) point type, will be setup such that an operator, by right-clicking the data object or graphic, will be able to command a digital value, or modify an analog value. Operators shall view equipment status from the menu. Menu items shall include headings for major equipment categories such as Air Handling Units, Boiler, Chillers, Zone Control, Lighting, etc. Cascading menus from each major category, shall allow the operator to select a particular piece of equipment; i.e. AHU-1 or Chiller.
 5. A maximum of 40 points will be provided in a single status display screen. Points that have been defined as data-writes, either as a digital (on/off) or analog (change value) point type, shall be setup such that an operator, by right-clicking the data object or graphic, shall be able to command a digital value, or modify an analog value.
- C. All Graphics and schedules will reside at the supervisory software level and not at the NAC level to allow for "one password" access to all NACs on the system and global scheduling and trending.

2.10 CUSTOM GRAPHICS - REQUIRED

- A. System Graphics: The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each sequence of operation indicated in temperature control drawings, and graphics that summarize conditions on each floor of each building included in this contract.
1. Screen Size/Text: Graphics shall be limited to a screen size of 1680x1050.
 2. Functionality: Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones, equipment, or alarms, and to edit setpoints and other specified parameters.
 3. Animation: Graphics shall be able to animate by displaying different image files for changed object status.
 4. Status Indication: Indicate status of system inputs and status of objects with the following colors.
 - a. Green: On/Running
 - b. Yellow: Off/Standby
 - c. Flashing Red: Alarm/Fault
 5. Descriptive Status Indication: Descriptive status of system inputs and status of objects shall use the English language descriptor for the object in such a way that the operator will be able to recognize the status without relying on acronyms or tables. HVAC equipment manufacturer's literature shall be used in developing the status descriptions.
 6. Setpoint Indication: Indicate control setpoint alarm deviations indicated in temperature control drawings with the following text colors. Deviations relative to setpoint shall have a time delay of 30min (adj.):
 - a. Black: Within Relative Setpoint Limits
 - b. Blue: Below Relative Setpoint Limits
 - c. Red: Above Relative Setpoint Limits

7. Format: Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Adobe Flash).

B. Home Page

1. The building site overview shall provide a "mouse over" function to highlight the floor plan area to be accessed as a navigational aid. Links to hydronic systems, power systems, schedules, alarms, and trends. Setpoint and operating point of each hydronic system, hydronic system status indications, and 12 month trends in histogram graphical format. Setpoint and operating point of each area, global equipment status indications, and 12 month trends in histogram graphical format. Performance of power monitoring systems and 12 month trends. Performance of natural-gas monitoring and 12 month trends in histogram graphical format. Domestic hot water system status indications. Fire alarm system status indication. Duress alarm indication. Critical data points, i.e. Outdoor Air Temperature, Outdoor Air Relative Humidity, Building Pressure, Hot Water Supply Temperature, Chilled Water Supply Temperature or National Weather Service data will be continuously visible, in real time, within the HTML frame on all screens. Additional points may be added or deleted at the owner's request without cost.

C. Floor Plans

1. Detailed floor plans shall be created with a vector drawing program accurately depicting the actual building layout to include all rooms, walls, and hallways. All space sensors shall be accurately placed in their actual locations and tagged with their real time space temperature and equipment each is associated with, i.e. 72.5°F/RTU-1, 74.2°/AHU-1, 73.4°/TU-1. Floor plans too large to be practically shown with data points will provide a "mouse over" function to highlight the floor plan area to be accessed. Room numbers and/or names will be included at the owner's request.

D. Mechanical Systems

1. Detailed graphics for each mechanical system shall include; AHUs, RTUs, HXs, CW Piping and Pumps, HW Piping and Pumps, HPs, TUs, and EFs as a minimum. Mechanical systems shall include on-screen access to their respective set-points, trend logs and schedule. All time schedules will be setup as directed by the owner prior to final job turnover.
2. Dynamic trends of all data points shall be set up (specification will be followed as to actual number of trend points possible) prior to final job turnover. Each trend will be available directly on screen for quick trend access.
3. Data points will be shown for all relevant inputs and outputs and be positioned near the actual device. Analog and digital parameters will be able to be modified directly from the equipment screen.

E. Terminal Units

1. Terminal units such as heat pumps, fan coil units, unit ventilators, reheat coils, booster coils and VAV boxes will depict the actual configuration of the equipment controlled. Actual equipment configurations from manufacturers web sites and/or photos of installed equipment shall be used to ensure graphic depictions are as "near actual" as possible.

F. Schedules

1. Graphical schedules shall allow the operator to adjust time of day schedules by dragging the On Event slider. An unlimited number of On/Off events shall be allowed for each schedule and schedules can be linked into a Master/Slave scheduling scheme. Schedules shall allow the user to add/edit/delete holiday and special event schedules. Schedules shall be included for each major piece of equipment.

G. Logging

1. Logs shall be provided for all points defined as requiring collection and archiving of their real-time values. Log data will be provided in HTML, XML, comma- and tab-separated value, and plain-text formats.
 - a. Each of the following of point types shall be continuously trended. The user shall have the ability to select up to 3 points to be displayed on a single trending graph.
 - 1) All Temperatures
 - 2) All Temperature setpoints
 - 3) All Damper Positions
 - 4) All VFD %
 - 5) All Airflows
 - 6) All Occupancy statuses
 - 7) All Enthalpies
 - 8) All Humidity's
 - 9) All CO2s
2. Setup parameters for each log include; log intervals, number of collection samples, log collection times and archive times, delta logging with change value selection, etc.
3. For every log, the data shall be viewable in both tabular and chart formats.
4. Logs shall be archived to the server software daily at a user specified time of day. Archive data shall be available from the creation time of the log until the last archive time.
5. For every log, the data can be viewed in both tabular and chart formats.
6. Logs and archives will be accessible from a Web Browser (Internet Explorer 5.0 or greater).
7. Analog Logs: Value Collected every 15 minutes for a log total of 2 days.

H. Energy Reports: System shall include an easily configured energy reporting tool that provides the capabilities described in this section.

1. The energy reporting tool shall be accessible through the same user interface (Web browser or operator workstation software) as is used to manage the BAS.
2. The energy reporting tool shall be preconfigured by the Contractor to gather and store energy demand and consumption data from each energy source that provides metered data to the BAS. Meter data shall be stored at 5 minute intervals. This data shall be maintained in an industry standard SQL database for a period of not less than five years.
3. The energy reporting tool shall allow the operator to select an energy source and a time period of interest (day, week, month, year, or date range) and shall provide options to view the data in a table, line graph, bar graph, or pie chart. The tool shall also allow the operator to select two or more data sources and display a comparison of the energy used over this period in any of the listed graph formats, or to total the energy used by the selected sources and display that data in the supported formats.
4. The energy reporting tool shall allow the operator to select an energy source and two time periods of interest (day, week, month, year, or date range) and display a graph that compares the energy use over the two time periods in any of the graph formats listed in the previous paragraph. The tool

shall also allow the operator to select multiple energy sources and display a graph that compares the total energy used by these sources over the two time periods.

5. The energy reporting tool shall allow the operator to easily generate the previously described graphs "on the fly," and shall provide an option to store the report format so the operator can select that format to regenerate the graph at a future date. The tool shall also allow the user to schedule these reports to run on a recurring basis using relative time periods, such as automatically generating a consumption report on the first Monday of each month showing consumption over the previous month. Automatically generated reports shall be archived on the server in a common industry format such as Adobe PDF or Microsoft Excel with copies e-mailed to a user editable list of recipients.
6. The energy reporting tool shall be capable of collecting and displaying data as indicated in temperature control drawings.
7. The user shall have the option of using Kw (Kwh), Therms/hr (Therms), CCF/hr (CCF), or Btu/hr (Btu) as the units for demand and consumption reports. Multiples of these units (MWH, kBtu, etc.) shall be used as appropriate. All selected sources shall be automatically converted to the selected units. The user shall similarly have the option of entering facility area and occupancy hours and creating reports that are normalized on an area basis, an annual use basis, or an occupied hour basis.
8. The user shall have the option of entering benchmark data for an individual facility or a group of facilities.
9. The user shall have the option of displaying any or all of the following data on any chart, line, or bar graph generated by the energy reporting tool:
 - a. Low/High/Average value of the metered value being displayed.
 - b. Heating and/or Cooling Degree Days for the time period(s) being displayed.
 - c. The Environmental Index for the facilities and time periods being displayed.

2.11 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacturer-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BMS, shall not be acceptable.
- C. The Web browser client shall support at a minimum, the following functions:
 1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
 2. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 3. Storage of the graphical screens shall be in the NAC or server software, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
 4. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
 5. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

- a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
 - 1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - 2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
 - b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - c. View logs and charts
 - d. View and acknowledge alarms
 - e. Setup and execute SQL queries on log and archive information
6. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
 7. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.12 SERVER SOFTWARE FUNCTIONS AND HARDWARE

- A. The server software shall be provided. The server software shall support all TCP/IP connected to the control system router.
- B. The Network server software shall provide the following functions, at a minimum:
 1. Global Data Access: The server software shall provide complete access to distributed data defined anywhere in the system.
 2. Distributed Control: The server software shall provide the ability to execute global control strategies based on control and data objects in any control system in the network, local or remote.
 3. The server software shall include a master clock service for its subsystems and provide time synchronization for all control systems.
 4. The server software shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
 5. The server software shall provide scheduling for all control systems and their underlying field control devices.
 6. The server software shall provide demand limiting that operates across all control systems. The server software must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
 7. The server software shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to control systems. Systems not employing this prioritization shall not be accepted.
 8. Each control system supported by the server software shall have the ability to archive its log data, alarm data and database to the Network server software, automatically. Archiving options shall be user-defined including archive time and archive frequency.
 9. The server software shall provide central alarm management for all control systems supported by the server software. Alarm management shall include:
 - a. Routing of alarms to display, printer, email and pagers

- b. View and acknowledge alarms
 - c. Query alarm logs based on user-defined parameters
- 10. The server software shall provide central management of log data for all control systems supported by the server software. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
 - a. Viewing and printing log data
 - b. Exporting log data to other software applications
 - c. Query log data based on user-defined parameters
- C. Server software Hardware Requirements: supplied by
 - 1. The system integrator will be responsible for loading and testing the software on the PC.
 - 2. The system integrator will coordinate with the owner for testing and authorization.

2.13 SYSTEM PROGRAMMING

- A. The Graphical Development Tool (GDT) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. The programming toolset will be provided to the owner as part of this project. The programming software shall be the same programming toolset as used by the contractor's engineers when programming this project. Access to the programming functions and features of the GDT shall be through password access as assigned by the system administrator.
- B. The GDT shall be available in two versions; a thick-client version licensed to the computing platform on which it is installed and a thin-client version, capable of providing the complete set of engineering functions through a standard Web Browser. Programming and development tools not capable of providing all engineering and application development functions with a standard Web Browser are not acceptable.
- C. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. All graphics must be created with a vector 3-D imaging software package, i.e., Dream Weaver, Illustrator, Cool 3-D or other commercially available graphics package.
- D. Programming Methods
 - 1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.

2. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real-time. Systems requiring the uploading on the owner's IT network, and downloading of database objects shall not be allowed.
5. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.14 OBJECT LIBRARIES

- A. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
- B. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
- C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.
- D. All control objects shall conform to the control objects specified in the BACnet specification.
- E. The library shall include applications or objects for the following functions, at a minimum:
 1. Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on-off events.
 2. Calendar Object. . The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
 3. Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals
 4. Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.
 5. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.

6. Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.
- F. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.
1. Analog Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
 2. Analog Output Object - Minimum requirement is to comply with the BACnet standard for data sharing.
 3. Binary Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.
 4. Binary Output Object - Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.
 5. PID Control Loop Object - Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.
 6. Comparison Object - Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
 7. Math Object - Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
 8. Custom Programming Objects - Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.

9. Interlock Object - Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.
 10. Temperature Override Object - Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.
 11. Composite Object - Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphical shell of this container.
- G. The object library shall include objects to support the integration of devices connected to the Network Area Controller or server software. At a minimum, provide the following as part of the standard library included with the programming software:
1. For BACnet devices, provide the following objects at a minimum:
 - a. BACnet AI
 - b. BACnet AO
 - c. BACnet BI
 - d. BACnet BO
 - e. BACnet MV
 - f. BACnet Device
 2. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

2.15 OTHER CONTROL SYSTEM HARDWARE

- A. Ethernet Switches
1. 8 Port 10/100 MBPS Switch / Hub
 2. Din Rail Mounted
 3. LED communication indicators
 4. Acceptable Manufacturers
 - a. Contemporary Controls
 - b. INTEL
 - c. Cisco Systems
- B. Temperature Sensors and Transmitters
1. General Sensor & Transmitter Requirements

- a. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, and as required to achieve the specified accuracy as specified herein.
 - b. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
 - c. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearities of the sensor and bridge and provide a true linear output signal.
 - d. Temperature sensors shall be of the resistance type and shall be 10K or 20K Ohm Thermistor type.
 - 1) Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the controllers operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical/expressions. Thermistors shall be of the Thermistor (NTC) Type with a minimum of 50 ohm/°C. resistance change versus temperature to insure good resolution and accuracy.
 - e. The following accuracy's are required and include errors associated with the sensor, lead wire and A to D conversion.
 - 1)

<u>Point Type</u>	<u>Accuracy</u>
Outside Air	+/-3%
Chilled/Hot Water	+/-1%
Room Temperature	+/-1%
Duct Temperature	+/-3%
 - 2) Sensors Used in Energy Water (BTU) or Process Calculations +/-1%
 - 3) Sensors used in energy or process calculations shall be accurate over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Bureau of Standards (NBS) Calibration Report Nos. 209527/222173.
2. Thermowells
- a. When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and Greenfield fitting, except where wells are to be installed under separate contract.
 - b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure
 - c. Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
 - d. Thermowells shall be constructed of the following materials:
 - 1) Hot Water; brass.
3. Outside Air Sensors
- a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
 - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
 - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
4. Duct Type Sensors

- a. Duct mount sensors shall mount in a hand box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
 - b. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Duct sensors probe shall be constructed of 304 stainless steel.
 - c. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.
 5. Averaging Duct Type Sensors
 - a. Where called out on the drawings and points lists, provide averaging type duct sensors. Thermistor sensors are acceptable. The sensor shall be multi-point sensitive through the length of the temperature conducting tubing. The thermistors shall be configured in a series / parallel method which creates an end result of total average resistance equal to the same span as a standard thermistor.
 - b. Provide capillary supports at the sides of the duct to support the sensing element.
 6. Acceptable Manufacturers
 - a. Honeywell
 - b. Johnson Controls
 - c. ACI
 - d. Bapi
- C. Relative Humidity Sensors/Transmitters
1. The sensor shall be a solid state, resistance type relative humidity sensor of the Bulk Polymer Design. The sensor element shall be washable and shall resist surface contaminations.
 2. Humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2 wire isolated loop powered, 4-20ma, 0-10.0 VDC linear proportional output.
 3. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion.
 - a. Room Type Sensor $\pm 2\%$ RH
 - b. Duct Type Sensor $\pm 2\%$ RH
 4. Outside air relative humidity sensors shall be installed in a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
 5. Provide a single point humidity calibrator, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
 6. Duct type sensing probes shall be constructed of 304 stainless steel and be equipped with a neoprene grommet, bushings and a mounting bracket.
 7. Acceptable Manufacturers:
 - a. Vaisala
 - b. ACI
 - c. Veris
 - d. Honeywell
 - e. Johnson Controls
- D. Differential Pressure Transmitters and Accessories
1. General Air and Water Pressure Transmitter Requirements:

- a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
 - b. Pressure transmitters shall provide the option to transmit a 0 to 5V dc, 0 to 10V dc, or 4 to 20 mA output signal.
 - c. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
 - d. Low air pressure, differential pressure transmitters used for room pressurization control (i.e. laboratories, OR's clean rooms, etc.) shall be equipped with a LED display indicating the transmitter output signal.
 - e. Duct sensing pressure applications where the velocity exceeds 1500 fpm shall utilize a static pressure traverse probes.
 2. Low Air Pressure Applications
 - a. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
 - 1) Span: Not greater than two times the design space DP.
 - 2) Accuracy: Plus or minus 0.5% of F.S.
 - 3) Dead Band: Less than 0.3% of output.
 - 4) Repeatability: Within 0.2% of output.
 - 5) Linearity: Plus or minus 0.2% of span.
 - 6) Response: Less than one second for full span input.
 - 7) Temperature Stability: Less than 0.05% output shift per degree change.
 - b. The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
 - c. Acceptable Manufacturers
 - 1) Auto Tran
 - 2) Veris
 - 3) Setra
 3. Medium to High Air Pressure Applications
 - a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter except the performance specifications are not as severe. Provide differential pressure transmitters which meet the following performance requirements.
 - 1) Zero & span: (% F.S./Deg. C): .05% including linearity, hysteresis and repeatability
 - 2) Accuracy: 1% F.S. (best straight line)
 - 3) Static Pressure Effect: 0.5% F.S.
 - 4) Thermal Effects: <±.05% F.S. /Deg. C.
 - b. Acceptable manufacturers:
 - 1) Auto Tran
 - 2) Veris
 - 3) Setra
- E. Electronic Valve And Damper Actuators
 1. General Requirements
 - a. Electronic actuators shall be electric, direct-coupled type capable of being mounted over the shaft of the damper. They shall be UL listed and the manufacturer shall provide a 2 year unconditional warranty from the date of commissioning. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA

for VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB for VAV actuators.

- b. Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burn-out. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.
 - c. Warranty must be two years by manufacturer on actuator as a whole and all components.
2. Air Terminals
- a. Air terminal actuators shall use fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controllers' requirements.

F. Switches

1. Strap-On Aquastat
- a. UL listed, provided with a suitable removable spring clip for attaching aquastat to pipe and a snap-action SPDT switch. Switch set-point shall be as indicated. Electrical rating shall be 5 amperes, 120 VAC.
2. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.

G. Flow, Pressure And Electrical Measuring Apparatus

1. Shielded Static Pressure Sensor
- a. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
 - b. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 feet/min. from a radial source.
 - c. The shielded static sensing devices shall be used for both reference and space pressure sensing.
 - d. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.
2. Static Pressure Traverse Probe
- a. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.
 - b. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
 - c. The duct static traverse probe shall be of 304 stainless steel construction and (except for 3/4" dia. probes with lengths of 24 inches or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of $\pm 1/2\%$.

d. Acceptable Manufacturers:

- 1) Auto Tran
- 2) Veris
- 3) Setra

H. Relays And Contactors

1. Relays other than those associated with digital output cards shall be general purpose, enclosed type and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
2. Solid State Relays (SSR): Input/output isolation shall be greater than $10E^9$ ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be $10 \times 10 E^6$ operations or greater. The ambient temperature range of SSRs shall be -18 to 140 deg F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.
3. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. Contractor shall be double-break-silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

I. Temperature Control Panels

1. Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. Panels shall conform to NEMA 1 standards, unless otherwise indicated.
2. Control panels shall meet all requirements of UL508A and shall be so certified.
3. All external wiring shall be connected to terminal strips mounted within the panel.
4. Provide engraved phenolic nameplates identifying all devices mounted on the face of control panels and the identification number of the panel.
5. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.

J. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
 - a. Unit shall operate between 0°C and 50°C (32°F and 122°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - b. Line voltage units shall be UL recognized and CSA listed.

K. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.

3. Minimum transverse-mode noise attenuation of 65 dB.
 4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.
- L. Room Sensors: Each room sensor shall provide temperature, humidity, and/or CO2 indication to the digital controller where indicated.
1. Room sensors shall include a local display for viewing space conditions, setpoints, occupancy, and other operator selectable parameters. User selectable parameters shall be able to lockout display of space conditions, setpoints, and other operator selectable parameters.
 2. Where manual overrides are indicated, provide software-limited set point adjustment and occupied/unoccupied override capability. Set point adjustment shall use buttons, no slides or wheels.
 3. Where indicated, provide plate type security temperature sensors.
- M. Duct smoke detectors shall be furnished and connected to the building fire alarm under Division 28. Contacts shall be provided for the BMS contractor to connect for fan shutdown as specified in the Sequence of Operations.
- N. Carbon Dioxide sensors shall be 0-10 Vdc analog output type, with corrosion free gold-plated Non-dispersive Infrared sensing, designed for duct mounting. Sensor shall incorporate internal diagnostics for power, sensor, analog and output checking, and Automatic Background Calibration algorithm for reduced maintenance. Sensor range shall be 0-3000 PPM with +/- 5% and +/- 50 PPM accuracy.
- O. Duct Mounted Airflow Measuring Station:
1. Provide where indicated, thermal airflow measuring stations capable of continuously monitoring the duct airflow.
 2. Each airflow probe array shall consist of one or more multi-point measuring probes and a single microprocessor based transmitter. The transmitter shall be supplied by the same manufacturer as the measuring station or probe array.
 3. Each multi-point probe shall be assembled using heavy wall anodized aluminum tubing, aluminum mounting plates, aerodynamically optimized molded sensing apertures to ensure accurate measurement in angular airflow conditions, and neoprene mounting gasket.
 4. The airflow measuring station housings shall have a 14 gauge galvanized steel, 8" deep welded casing with 90° connecting flanges. If minimum straight inlet duct diameters are not met, a 3" deep aluminum honeycomb air straightener positioned in front of the measuring probes shall be furnished. The maximum allowable unrecovered pressure drop caused by the station shall not exceed .08" w.c. at 2000 FPM.
 5. Each airflow sensor shall have an operating range of 150-5000 FPM, with a NIST traceable accuracy of $\pm 2\%$ of reading for velocity measurement and 0.1°F for temperature measurement.
 6. When installed per the manufacturer's minimum installation requirements, the transmitter with accompanying station probes shall measure with an accuracy of $\pm 2-3\%$ of actual flow.
 7. The airflow probes shall be Air Monitor ELECTRA/flo/M, /CM, or Ebtron Gold series GTx116. with class "C" density.

PART 3 - EXECUTION

3.1 GENERAL

- A. The BMS shall be designed, installed, and commissioned in a turnkey operational manner; including all labor not noted in Work by Others paragraph of PART I of this section of these specifications, and not noted in other sections of these specifications.
- B. Where control devices are installed on insulated piping or ductwork, provide standoff brackets or thermowells sized to clear insulation thickness. Provide extended sensing elements, actuator linkages, and other accessories as required.

3.2 COORDINATION

- A. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment/replacement. If the controls contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the controls contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
- B. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.
- C. Test and Balance:
 - 1. The controls contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
 - 2. The controls contractor shall provide training in the use of these tools. This training will be planned up to 4 hours.
 - 3. In addition, the controls contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
 - 4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.
- D. Life Safety:
 - 1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as indicated in temperature control drawings.
 - 2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as indicated in temperature control drawings.
 - 3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.
- E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the controls contractor as follows:
 - 1. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation described in temperature control drawings.

2. The controls contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
3. The controls contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
4. The controls contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.3 INSTALLATION

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of zone sensors, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices at the same location as light switches above the floor as noted on drawings or owner's direction.
 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- D. Install automatic dampers according to Section 23 3xxx "Air Duct Accessories."
- E. Install labels and nameplates to identify control components according to Section 23 0553 "Identification for HVAC Piping and Equipment."
- F. Install hydronic instrument wells, valves, and other accessories according to Section 23 2xxx Hydronic Piping Specialties."
- G. Install duct volume-control dampers according to Section 23 3xxx "Metal Ducts" and "Nonmetal Ducts."
- H. Installation of Sensors: Install sensors in accordance with the manufacturer's recommendations.
 1. Mount sensors rigidly and adequately for environment within which the sensor operates.
 2. Room sensors shall be installed on concealed junction boxes properly supported by wall framing.
 3. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.
 4. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
 5. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft of sensing element for each 1 ft² of coil area.
 6. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 ft. downstream.
 7. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.
 8. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
 9. Differential Air Static Pressure:

- a. Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum. Supply duct static pressure sensors shall be installed 2/3 from the first duct takeoff or prior to any fire and/or smoke dampers, whichever is nearest to the supply fan.
 - b. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor. Return duct static pressure sensors shall be installed 2/3 from the first duct takeoff or prior to any fire and/or smoke dampers, whichever is nearest to the return fan.
 - c. Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a zone sensor cover located at the lowest level the system serves.
 - d. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - e. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
 - f. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.
10. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
- I. Actuators: General. Mount and link control damper actuators according to manufacturer's instructions. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions. Provide all mounting hardware and linkages for actuator installation.
1. Electric/Electronic:
- a. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer's recommendations. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Section 26 0533 "Raceways and Boxes for Electrical Systems."
 - B. Install building wire and cable according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 - C. Install signal and communication cable according to Division 27 "Communications Horizontal Cabling."
1. Conceal exposed cable or install exposed cable in raceway or electrical metallic tubing.

2. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 3. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 4. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 5. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.5 CONTROLLERS

- A. Provide a separate controller for each system indicated in temperature control drawings to provide stand-alone control in the event of communication failure. Where multiple systems of the same type exist, each system shall be controlled by a single controller. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Additional controllers are allowed to be used where com links exceed the limits specified above or where a controller has reached its maximum capacity. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
- B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in temperature control drawings.

3.6 PROGRAMMING

- A. Provide sufficient internal memory for the specified sequences of operation and trend logging.
- B. Software Programming:
1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the controls contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:
 - a. Text-based:
 - 1) Must provide actions for all possible situations
 - 2) Must be modular and structured
 - 3) Must be commented
 - b. Graphic-based:
 - 1) Must provide actions for all possible situations
 - 2) Must be documented
 - c. Parameter-based:
 - 1) Must provide actions for all possible situations

2) Must be documented.

C. Operator Interface:

1. Graphics: Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, all terminal equipment, and graphics for each sequence of operation indicated in temperature control drawings. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List indicated in temperature control drawings.
2. The controls contractor shall provide all the labor necessary to initialize, start up, and troubleshoot all software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.7 CONTROL SYSTEM CHECKOUT AND TESTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Notify commissioning authority prior to starting control system checkout and testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
3. Test and adjust controls and safeties.
4. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
5. Test each point through its full operating range to verify that safety and operating control set points are as required.
6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
7. Test each system for compliance with sequence of operation.
8. Test software and hardware interlocks.
 - a. Check each alarm with an appropriate signal at a value that will trip the alarm.
 - b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
 - c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 6. Check temperature instruments and material and length of sensing elements.
 7. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that control panels contain laminated ladder wiring diagrams of equipment being controlled.
 - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.8 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.

11. Provide written description of procedures and equipment for calibrating each type of instrument.

- B. Adjust initial temperature and humidity set points.
- C. Occupancy Adjustments: When requested within 24 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose. During this time period, modify default setpoints to reflect overridden adjustments.

3.9 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- A. Demonstration: Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the controls contractor has completed the installation, started up the system, and performed his/her own tests. Provide technicians, instrumentation, tools, and equipment to test performance of instrumentation and control for HVAC systems, at the direction of the commissioning authority. Refer to Division 01 Section "General Commissioning Requirements" for functional performance testing procedures.
- B. Acceptance: If the commissioning authority determines that equipment and systems operate satisfactorily at the end of the final start-up, testing, and commissioning phase, commissioning authority will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Any tests that cannot be performed due to circumstances beyond the control of the controls contractor may be exempt from the completion requirements if stated as such in writing by the commissioning authority. Such tests shall then be performed as part of the warranty. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."
- C. Site Backup: Perform complete site backup of building control system for turnover to owner.

3.10 TRAINING

- A. All training shall be by the BMS Installer and shall utilize operators' manuals and as-built documentation.
- B. The controls Installer shall provide 40 hours of instruction to the Owner's designated personnel on the operation of the BMS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BMS shall include, but not be limited to; device programming software, graphical development software, graphical user interface, the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation. Video record the training sessions. Coordinate with general contractor for additional demonstration and training requirements.
- C. The training shall be in three sessions as follows:
 - 1. Initial Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the Owners' personnel can start to familiarize themselves with the system before training begins.
 - 2. Follow-Up Training: Two one day sessions (8 hours each) after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics and answer questions.

3. Warranty Follow Up: Two one day sessions (8 hours each) to be scheduled at the request of the Owner during the one year warranty period. These sessions shall cover topics as requested by the owner such as; how to add additional points, create and gather data for trends, graphic screen generation or modification of control routines.
- D. On-Line Service: Include 40 hours of on-line service assistance to include but not be limited to:
 1. Programming changes or modifications, including changes and adjustments to control algorithms
 2. Graphic changes or modifications as requested by the Owner or consulting engineer.
 3. Operator assistance to include short (1 hour or less) refresh training on system diagnostics and operation, i.e., geothermal optimization, scheduling, trending or operator setup.
 4. Consulting engineer assistance to include assistance on control system optimization.

END OF SECTION 25 5000

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SECTION 26 0500 - 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Electrical Scope of work
 - 2. Electrical equipment coordination and installation.
 - 3. Rough-in
 - 4. Electrical Demolition
 - 5. Common electrical installation requirements.

1.3 SCOPE OF WORK

- A. The scope of work is to include but not be limited to the following:
 - 1. Obtain all required electrical construction permits and inspections.
 - 2. File electrical service request with the Electric Utility for a new (upgraded, primary, secondary) electrical service.
 - 3. Provide cash allowance in bid for utility installation charges.
 - 4. Provide concrete pad and conduit for service transformer installation.
 - 5. Provide a 277/480 volt, 3 phase, 4 wire, distribution system for lighting and HVAC equipment.
 - 6. Provide a 120/208 volt, 3 phase, 4 wire, distribution system for convenience receptacles, small appliances and small motors.
 - 7. Refer to mechanical drawings, security, communications and access control drawings. Provide low voltage raceways (1/2" minimum) for all thermostats, controls and low voltage systems. No low voltage wiring of any type shall be visible in exposed ceiling areas.
 - 8. Provide complete electrical installation including all components, i.e. light fixtures, lamps, receptacles, conduit, wire, etc.
 - 9. Provide fire alarm devices.
 - 10. Provide raceway system for sound system, clock/program system, and security system.
 - 11. Provide raceway system for telephone/data networking systems.
 - 12. Provide for Owner training by factory representatives in operation and maintenance of systems where specified.
 - 13. Overcurrent protective devices installed into existing equipment shall meet or exceed the rating of that equipment. Series ratings will not be accepted.
 - 14. Provide selective demolition of electrical systems and equipment as indicated on the drawings.

15. Submit documentation such as shop drawings, record documents, maintenance manuals, infrared scan results, systems test results, fire alarm system certification, etc. as specified.

1.4 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. Such that 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 electrical systems, equipment and materials installation with other building components.
- C. Coordinate installation of electrical panelboard tubs, backboxes and concealed conduit and tubing with masonry/concrete work. Standing surface of working area must be level and as flat as possible per NFPA70 110.26A6.
- D. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.
- E. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- F. 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 08 Section "Access Doors and Frames."
- G. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

1.5 INTERPRETATIONS

- A. It is the intent of these Drawings and Specifications to result in a complete electrical installation in complete accordance with applicable code and ordinances.
- B. Drawings are diagrammatic in character and do not necessarily indicate every required junction box, pull box, ell, etc. Items not specifically mentioned in the specification or noted on the Drawings, but which are necessary to make a complete working installation, shall be included.
- C. Drawings and Specifications are complementary. Whatever is called for in either is binding as though called for in both. The more stringent requirement shall govern.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 ELECTRICAL DEMOLITION

- A. Disconnect, demolish, and remove electrical system equipment and components indicated to be removed.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- C. Inaccessible Work: Cut and remove buried raceway and wiring, indicated to be demolished, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- D. All existing fixtures, equipment, etc., that are removed and not indicated to be relocated, or reused, shall first be offered to the Owner, after Owner has approved, the remaining removed items shall become property of the Contractor and shall be removed from the building site.
- E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.
- F. Protect existing electrical equipment and installations not indicated to be removed. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- G. Contractor shall examine the Drawings and Specifications, and existing conditions. All costs relating to maintaining existing services or relocating existing circuits and/or equipment shall be included in the bid. Contractor is required to complete all work necessary to meet these requirements without additional expense to the Owner or his Representative.
- H. Equipment Replacement: Contractor shall verify all circuit breakers and fuse sizes against the existing wire size prior to replacing switchboards, panelboards and disconnect switches. Notify the Architect of any discrepancies prior replacing equipment.

3.2 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 02 through 49 for rough-in requirements.

3.3 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1, Standard Practices for Good Workmanship in Electrical Construction.
- B. Arrange for chases, slots and openings in other building components during progress of construction, to allow for electrical installations.

- C. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
- D. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
- E. Measure indicated mounting heights to bottom of unit for suspended items and to bottom of unit for wall-mounting items or as indicated on drawings.
- F. 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.
- G. 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.
- H. Right of Way: Give to piping systems installed at a required slope.

3.4 FIRESTOPPING

- A. 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 07 Section "Penetration Firestopping."

END OF SECTION 26 0500

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.2 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.3 CLOSEOUT SUBMITTALS

- A. Dated documentation of torque values of cable connections on all equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Conductor Material: Copper complying with NEMA WC 70/ICEA S-95-658.
- B. Conductor Insulation Types: Type THHN-2, THWN-2, Type XHHW-2, Type RHW2 and Type SO

2.2 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

- 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 70.

PART 3 - EXECUTION

3.1 CONDUCTOR AND INSULATION APPLICATIONS

- A. Minimum conductor size for power wiring #12 AWG.
- B. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
- C. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- D. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- E. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- F. Exposed Branch Circuits, including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- H. Fixture Whips: Type MC cable may be used for light fixture whips only, with a maximum length of 6 feet.
- I. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-2-THWN-2, single conductors in raceway.
- J. Underground Feeders and Branch Circuits: Type THHN-2-THWN-2, single conductors in raceway.
- K. Fire Alarm Circuits: UL2196 rated cabling in raceway or Power-limited, fire-protective, signaling circuit cable where raceway is not specified.
- L. Class 1 Control Circuits: Type THHN-2-THWN-2, in raceway.
- M. Class 2 Control Circuits: Type THHN-2-THWN-2, in raceway or Power-limited cable, concealed in building finishes where raceway is not specified.
- N. Dimming Control Circuits: Provide 600V rated cabling for 0-10V dimming circuits. Wiring to be installed in conduit where exposed. Install in accordance with the proper class 1 or class 2 circuit requirements as required by the lighting control system used.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

- A. Where 120 volt, 20 amp, branch circuit wiring from panelboard to first outlet exceeds 100 feet in length, increase home-run wire size to #10 AWG.
- B. Where 277 volt, 20 amp, branch circuit wiring from panelboard to first light fixture exceeds 150 feet in length, increase home-run wire size to #10 AWG.

- C. Common neutral conductors **shall not** be used for convenience outlet or lighting branch circuits.
- D. Neutral conductors shall be clearly labeled at the panelboard with the circuit number of associated phase conductors.
- E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- I. Support cables according to Division 26 Section "Common Work Results for Electrical."
- J. Seal around cables penetrating fire-rated elements according to Division 07 Section "Penetration Firestopping."
- K. Cable tie tightness where applicable shall be per NECA and UL standards, do not over tighten.
- L. One-hour and Two-hour cables should be installed using components specified in appropriate FHIT document and Manufacturer Installation guide. Substitutions are not permitted.

3.3 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.4 CONNECTIONS

- A. 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 and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 0519

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Grounding systems and equipment.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grounding Conductors, Cables, Connectors, and Rods:
 - a. Copperweld Corp.
 - b. Erico Inc.; Electrical Products Corporation.
 - c. FCI Burndy Products.
 - d. Ideal Industries, Inc.
 - e. ILSCO.
 - f. Kearney/Cooper Power Systems.
 - g. O-Z/Gedney Co.; a business of the EGS Electrical Group.
 - h. Raco, Inc.; Division of Hubbell.
 - i. Thomas & Betts, A Member of the ABB Group.

2.2 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Material: Copper.
- C. Equipment Grounding Conductors: Insulated with green-colored insulation.
- D. Grounding Electrode Conductors: Stranded cable.
- E. Underground Conductors: Bare stranded unless otherwise indicated.
- F. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- G. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.3 CONNECTOR PRODUCTS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Compression Connectors: Irreversible hydraulic compression kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- E. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long barrel, two-bolt connection to ground bus bar

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Sectional type; copper-clad steel.
 - 1. Size: 3/4 inch in diameter by 120 inches long.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermic-Welded or Irreversible Compression Connections: Use for connections to structural steel and for underground connections.
- D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.
- E. Install equipment grounding conductors or grounding electrode conductors that are routed through exposed ceiling spaces in conduit.
- F. Label equipment grounding conductors and grounding electrode conductors as indicated in "Identification for Electrical Systems".
- G. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- H. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.
- I. Grounding Bus: Install in electrical service equipment rooms.
 - 1. Size: 1/4 inch by 2 inches bare, annealed copper.
 - 2. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
 - 3. At doors, route the bus up to the top of the door frame, across the top of the doorway, and down to the specified height above the floor.
- J. Underground Grounding Conductors: Use tinned-copper conductor, No. 2/0 AWG minimum unless noted otherwise. Bury at least 24 inches below grade.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
 - 1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
 - 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
 - 1. Drive ground rods until tops are 6 inches below finished floor or final grade, unless otherwise indicated.
 - 2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except as otherwise indicated. Make connections without exposing steel or damaging copper coating.
 - 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
 - 4. Bond all steel structure and concrete reinforcement steel / rebar.
- D. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to

- building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. Concrete-Encased Electrodes: Connect grounding conductor to the foundation reinforcing bars or rods and bond the bars together with steel tie wires.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- G. Grounding Variable-Frequency Motors: Provide copper braided grounding strap between motor and metallic conduit (EMT or IMC) in addition of the equipment grounding conductor on motors controlled with a variable-frequency controller.

3.4 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- E. Tighten screws and bolts for grounding and bonding 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.
- F. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Duct Banks: Install a grounding conductor with at least 50 percent ampacity of the largest phase conductor in the duct bank.
- B. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation.

3.6 LABELING

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Make tests at ground rods before any conductors are connected.
- B. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.
 - 5. Manhole Ground: 10 ohms.
- C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 0526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.

- e. Thomas & Betts Corporation/ A Member of the ABB Group.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
- 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
- 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 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 scheduled in NECA 1, where Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch 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 trapeze member with clamps approved for application.
 2. 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 and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- E. Provide independent support rings/shepherd hooks for any low voltage communications systems cabling. Cabling shall not rest on ceiling and shall be organized neatly on hooks. Cable shall not be visible in exposed ceiling spaces.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 for installation requirements, except as specified in this Article.

- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.
- C. Install seismic-restraint components using methods approved by the evaluation service providing required submittals for component.
- D. 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.
- E. 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 thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, 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.
- F. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 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.
- D. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 0529

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SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Boxes, enclosures, and cabinets.

1.2 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.

1.3 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, hand holes and attachment details.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

1.5 COORDINATION

- A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. GRC: Comply with ANSI C80.1 and UL 6.
- C. EMT: Comply with ANSI C80.3 and UL 797.
- D. FMC: Comply with UL 1; zinc-coated steel.
- E. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- F. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew or compression.
 - 2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- G. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ENT: Comply with NEMA TC 13 and UL 1653.
- C. RNC: Type EPC-40-PVC and EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. LFNC: Comply with UL 1660.
- E. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- F. Fittings for LFNC: Comply with UL 514B.

2.3 PVC COATED RIGID METAL CONDUIT

- A. The PVC coated rigid metal conduit shall be hot dip galvanized inside and out. The interior galvanizing shall be listed per UL 6. The exterior galvanizing shall be listed per UL 6 as primary corrosion protection.

Thread protectors shall be used on the exposed threads of the PVC coated conduit. PVC coated RMC steel conduit shall comply with UL 6, ANSI C80.1, and NEMA RN-1 standards without exception.

- B. The PVC coating, in compliance with NEMA RN-1, shall be nominal 40 mils in thickness continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles or pin- holes. PVC shall be UL listed as a primary corrosion protection.
- C. A urethane coating shall be uniformly and consistently applied to the interior of conduit. This internal coating shall be a nominal 2 mils thickness. All male threads on elbows and nipples shall be zinc coated using zinc rich paint.
- D. Coated couplings shall be used with coated conduit. The thickness of the coating on couplings shall be at least equal to the thickness of the coating on the conduit. Each coated coupling shall have a flexible PVC sleeve which extends from each end of the coupling and which will overlap the PVC coating on the conduit when the coupling has been installed on the conduit. The length of the sleeve extension(s) shall be at least equivalent to the nominal Trade Size for sizes 1/2" up through 1-1/2". For Trade Size 2" through 6", the length of the sleeve extension(s) shall be at least 2 inches. The PVC sleeve shall be a nominal thickness of 40 mils in thickness. The inside diameter of the overlapping sleeve shall be less than the outside diameter of the PVC-coated conduit.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Metal Floor Boxes:
 - 1. Material: Sheet-metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.

- I. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.
- J. Telephone/Data Backboxes: Provide 2-gang, 3 ½ inch deep backboxes with single gang raised cover unless noted otherwise on plans.
- K. Low Voltage Boxes: 5-Square telecommunications outlet boxes (5 in. square x 2.875 deep w/ cable management) shall be used for all low voltage applications. 5-square box shall support 5e, 6, augmented 6, 7, and optical fiber cables. Low voltage boxes shall support integral cable management by allowing slack cable to be wound internally while maintaining minimum bend radius requirements. 5-square boxes shall also be used for all fire alarm applications.

2.5 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard gray paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

2.6 CABLE PATHWAY AND FIRESTOP DEVICE

- A. Manufacturer:
 - 1. Specified Technologies, Inc., EZ-Path fire rated pathway.
 - 2. Wiremold, FlameStopper FS Series thru-wall fitting for fire walls.
- B. Description: Through-the-wall 3" x 3" steel wiring channel or 4" EMT equipped with heat expanding intumescent fire stopping material.
- C. Wiring channel shall be provided with steel wall plates allowing for single or multiple channels to be ganged together.
- D. Wiring channel shall have an F rating equal to the rating of the barrier in which it is installed.
- E. Wiring channel shall be capable of allowing a 0 to 100 percent visual fill of cable.
- F. Wiring channel shall be tested in accordance with ASTM E 814 (ANSI/UL1479). Channel shall bear the UL classification marking.
- G. Provide the quantity of devices needed to allow a cable pass cross section capacity of 50 percent of the adjacent cable tray cross section.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors:

1. Exposed: Rigid steel. (No RNC Allowed)
2. Concealed, Aboveground: Rigid steel.
3. Underground: RNC Schedule 80.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures: NEMA 250, Type 3R or 4.

B. Indoors:

1. Exposed in Unfinished Utility Spaces (mechanical rooms, electrical rooms and tunnels): EMT.
2. Exposed in Finished Spaces: All conduit shall be concealed unless specifically indicated on plans.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit.
4. Concrete Floors: RNC.
5. Concealed in Ceilings and Interior Walls and Partitions: EMT
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
7. Damp or Wet Locations: Rigid steel conduit.
8. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
 - a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.

C. Minimum Raceway Size: 3/4-inch trade size(21mm).

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this Article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Provide separate raceways for lighting, receptacle, and motor loads. Do not mix branch circuit wiring for these different loads in the same raceway.
- C. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- D. Complete raceway installation before starting conductor installation.
- E. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Support raceways as specified in Division 26 Section "Common Work Results for Electrical."
- G. Install temporary closures to prevent foreign matter from entering raceways.

- H. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above finished slab.
- I. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- J. Make bends and offsets so ID is not reduced. Keep legs of bends in same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- K. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
 - 1. Install concealed raceways with a minimum of bends in shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
 - 2. Conduit and EMT may be surface mounted in Mechanical and Electrical Rooms except for wiring devices, light switches, low voltage devices or any other device shall be concealed in new wall.
 - 3. Surface mounted conduit or EMT may be used where specifically approved by Architect/Engineer. In such situations, the conduit, fastening devices, and junction boxes shall be painted to match the adjacent surface.
- L. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches of concrete cover.
 - 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
 - 2. Space raceways laterally to prevent voids in concrete.
 - 3. Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 4. Change from nonmetallic tubing to rigid steel conduit before rising above floor or grade.
- M. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
 - 1. Run parallel or banked raceways together on common supports.
 - 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- N. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- O. Join raceways with fittings designed and approved for that purpose and make joints tight.
 - 1. Use insulating bushings to protect conductors.
- P. Tighten set screws of threadless fittings with suitable tools.
- Q. Terminations:
 - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.

2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
 3. Telephone, data and fiber optic cable conduits shall be provided with bushings on conduit ends.
- R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- S. Color-Coding: Paint fire alarm system junction boxes and covers red.
- T. Raceways for Optical Fiber and Communications Cable: Install as follows:
1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
 2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- U. Telephone, data, AV, security, access control, fiber optic cable system, building control cabling, lighting control, 0-10V dimming control and any other low voltage systems cabling shall be installed in conduit in areas of exposed ceiling. In areas with accessible ceilings, the low voltage systems cables shall be neatly routed and independently supported with cable rings to the nearest cable tray, technology closet, conduit run or equipment connection. Systems to be in conduit in accessible ceiling spaces where required elsewhere in the specification or drawings.
- V. Telephone, data and fiber optic cable system conduit shall be provided with wide sweep bends.
- W. Telephone, data and fiber optic cable outlets shall be provided with a 1 inch conduit stubbed into accessible ceiling space unless noted otherwise on the drawings. Provide bushings on the ends of the conduit.
- X. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where otherwise required by NFPA 70.
- Y. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

- d. Attics: 135 deg F temperature change.
- 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
- 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
- 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- Z. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- AA. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.
- BB. Flexible Connections to Lighting Fixtures:
 - 1. Above ceilings that are continuous to wall: Provide flexible conduit to all recessed lighting fixtures, maximum length as indicated. For fixtures mounted on grid ceilings, provide adequate length of flexible conduit to allow relocation of fixture on grid space in any lateral direction.
 - 2. Above clouds or above suspended ceiling elements that are visible and exposed, Flexible Connections to Lighting Fixtures shall be limited to reduce sight of flexible conduit. Flexible connections to light fixtures shall not be visible from standing on the floor or nearby landings or overlooks. Minimize angle of visibility, run EMT as necessary and coordinate with trades to group systems to minimize drops. All drops to element/cloud to be EMT and shall not be flex.
- CC. Equipment Grounding Conductor: Install a green equipment grounding conductor in all flexible conduit and non-metallic (PVC) conduit.
- DD. Recessed back-to-back boxes are not permitted in the same wall. Arrange boxes with at least 12 inches of horizontal spacing.
- EE. Recessed Boxes in Masonry Walls: Saw-cut opening for box in masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
- FF. Locate boxes so that cover or plate will not span different building finishes.
- GG. Set floor boxes level and flush with finished floor surface.
- HH. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
- II. Provide stainless steel cover plates on all abandoned boxes that remain from selective demolition.

- JJ. Cable pathway and firestop device: Install in locations where indicated on the plans. Arrange singly or in gangs and mounted above accessible ceilings. Install the devices in strict accordance with the manufacturer's recommendations.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout length elbow.
5. Transition from PVC-Schedule 80 (RNC) to RMC underground, no RNC conduit shall exposed outdoors or inside building.
6. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
7. Underground Warning Tape: Comply with requirements in Section 26 0553 "Identification for Electrical Systems."

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.5 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.6 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

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1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.7 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 26 0533

SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Conduit, ducts, and duct accessories for direct-buried duct banks.

1.2 ACTION SUBMITTALS

- A. Product Data: For accessories for manholes, handholes, and boxes.
- B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI C2.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARNCO Corp.
 2. Beck Manufacturing.
 3. Cantex, Inc.
 4. CertainTeed Corp.; Pipe & Plastics Group.
 5. Condux International, Inc.
 6. ElecSys, Inc.
 7. Electri-Flex Company.
 8. IPEX Inc.
 9. Lamson & Sessions; Carlon Electrical Products.
 10. Manhattan/CDT; a division of Cable Design Technologies.
 11. Spiraduct/AFC Cable Systems, Inc.
- C. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
- D. Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
 2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.
- D. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.2 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations, unless otherwise indicated.

- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- E. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- F. Pulling Cord: Install 100-lbf- test nylon cord in ducts, including spares.
- G. Direct-Buried Duct Banks:
 - 1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 - 2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
 - 3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
 - 4. Install backfill as specified in Division 31 Section "Earth Moving."
 - 5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
 - 6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
 - 7. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.
 - 8. Set elevation of bottom of duct bank below the frost line.
 - 9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
 - 10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

3.3 GROUNDING

- A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts.
 - 2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.5 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 26 0543

SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Silicone sealants.
- B. Related Requirements:
 - 1. Division 07 Section "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Exterior Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized sheet steel.

2. Minimum Metal Thickness:

- a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
- b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

- a. Advance Products & Systems, Inc.
- b. CALPICO, Inc.
- c. Metraflex Company (The).
- d. Pipeline Seal and Insulator, Inc.
- e. Proco Products, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

- a. Presealed Systems.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Sealant shall have VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. 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 07 Section "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install 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.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 0544

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.

1.2 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.4 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.4 NAMEPLATES AND SIGNS

- A. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
- B. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.
- C. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.

- D. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
4. Not less than 6 inches wide by 4 mils thick.
5. Compounded for permanent direct-burial service.
6. Embedded continuous metallic strip or core.
7. Printed legend indicating type of underground line.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.6 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches.

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.7 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
- C. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- E. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- F. Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" in black letters 2 inches high, stenciled with paint at 10-foot intervals over a continuous, painted orange background. Identify the following:
 - 1. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to conduits concealed within wall.
 - 3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
 - 4. Entire surface of exposed conduits.
- G. Install painted identification according to manufacturer's written instructions and as follows:
 - 1. Clean surfaces of dust, loose material, and oily films before painting.
 - 2. Prime surfaces using type of primer specified for surface.
 - 3. Apply one intermediate and one finish coat of enamel.
- H. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

- I. Circuit Identification on Device Plates.
 - 1. Identify circuits feeding receptacles with the designation of the panelboard and the circuit number in permanent marker on the back of each device cover plate.
 - 2. In mechanical, technology closets, electrical rooms and industrial type spaces, provide typed self-adhesive plastic labeling on outside of cover-plate to indicate the circuit number.
- J. Circuit Identification Labels on Boxes: Install labels externally.
 - 1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
 - 2. Concealed Boxes: Plasticized card-stock tags.
 - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- L. Underground-Line Warning Tape: During backfilling of trenches, install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Install labels at 20-foot maximum intervals.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. Power.
- C. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branch-circuit phase conductors:
 - 1. 208/120-V Conductors:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - 2. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:
 - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch- wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.

- b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.
- D. Provide labelling of each independent, conductors at 50' maximum centers, label at equipment and label at bus bars. Separate ground conductors routed concealed within conduit shall have conduit labels to identify the grounding conductor equipment or grounding/bonding location.
 - a. Indicate what equipment is fed or where the equipment is fed from on the label.
 - b. At service grounding bus bar, label "service grounding electrode conductor" at service entrance ground and label the equipment served by each equipment ground conductor.
- E. Apply identification to conductors as follows:
 - 1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
 - 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
 - 3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
- F. Apply warning, caution, and instruction signs as follows:
 - 1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 - 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- H. Disconnecting means: Provide equipment information or purpose of disconnect. Per NFPA requirements:
 - 1. Indicate circuit source panel and number that supplies disconnecting means unless it is apparent.
 - 2. Indicate location of source panel that supplies disconnecting means.
- I. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch- high lettering on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
 - 1. Panelboards, electrical cabinets, and enclosures.
 - 2. Access doors and panels for concealed electrical items.
 - 3. Disconnect switches.
 - 4. Enclosed circuit breakers.
 - 5. Motor starters.

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**IDENTIFICATION FOR ELECTRICAL SYSTEMS
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6. Push-button stations.
7. Contactors.
8. Remote-controlled switches.
9. Dimmers.
10. Control devices.
11. Clock/program master equipment.
12. Call system master station.
13. Fire alarm control panel.
14. Security-monitoring master station or control panel.

END OF SECTION 26 0553

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SECTION 26 0573 - COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For computer software program to be used for studies.
 - 2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - a. Coordination-study input data, including completed computer program input data sheets.
 - b. Study and equipment evaluation reports.
 - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
 - 1. For Power System Analysis Software Developer.
 - 2. For Power Systems Analysis Specialist.
 - 3. For Field Adjusting Agency.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.

- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
- D. Power System Analysis Software Qualifications:
 - 1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
 - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- F. Field Adjusting Agency Qualifications:
 - 1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
 - 2. A member company of NETA.
 - 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. Comply with IEEE 242 and IEEE 399.
- B. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 COORDINATION STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.

5. Switchgear, switchboard, motor-control center, and panelboard designations.
 6. Any revisions to electrical equipment required by the study.
 7. Study Input Data: As described in "Power System Data" Article.
 - a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0573 "Short-Circuit Studies."
- D. Protective Device Coordination Study:
1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, and ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.
- E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
 4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - e. Ground-fault protective devices.
 - f. The largest feeder circuit breaker in each motor-control center and panelboard.
 5. Maintain selectivity for tripping currents caused by overloads.
 6. Provide adequate time margins between device characteristics such that selective operation is achieved.
 7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the overcurrent protective device study.
 - 1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Architect's attention.
 - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

3.3 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

K. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of panelboard bus bars to withstand short-circuit stresses.
3. Include in the report identification of any protective device applied outside its capacity.

3.4 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.5 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 26 0573

SECTION 26 0800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commissioning process requirements for communications systems, electronic safety and security systems, and electrical systems, assemblies, and equipment.
- B. Related Documents:
 - 1. The OPR and BOD documentation are included by reference for information only.
- C. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.
 - 2. Division 22 Section "Commissioning of Plumbing" for plumbing commissioning requirements.
 - 3. Division 22 Section "Commissioning of HVAC" for HVAC&R commissioning requirements.

1.2 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. Red-Lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:
 - 1. Contractor will provide a copy of O&M literature within 45 days as requested by the CxA.
 - 2. The CxA will review the O&M literature once for conformance to project requirements.
 - 3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. Demonstration and Training:
 - 1. Contractor will provide demonstration and training as required by the specifications.
 - 2. A complete training plan and schedule must be submitted by the Contractor to the CxA.
 - 3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
 - 4. The CA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CA and Owner's representative. A copy of the test record shall be provided to the CA, Owner, and Architect.
 - 5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
 - 6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
 - 7. Review data in O&M Manuals.
- E. Systems Manual Requirements:
 - 1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
 - 2. The GC shall include final approved versions of the following information for the Systems Manual:
 - a. As-Built System Schematics
 - b. Verified Record Drawings

- c. Test Results (not otherwise included in Cx Record)
 - d. Periodic Maintenance Information for computer maintenance management system
 - e. Recommendations for recalibration frequency of sensors and actuators
 - f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
 - g. Training Records, Information on training provided, attendees list, and any on-going training
- 3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
 - 4. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
 - 5. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend commissioning meetings.
- C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- D. Provide information requested by the CxA for final commissioning documentation.
- E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- F. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.
- G. Update schedule as required throughout the construction period.
- H. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.
- I. Assist the CxA in all verification and functional performance tests.
- J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications.
- L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- M. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

- N. Coordinate and schedule all training with Owner personnel.
- O. Communicate all training with CM and CxA.
- P. Provide written notification to the General Contractor and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Electrical equipment including panel boards, lighting, receptacles, dimmers and all other equipment furnished under this Division.
 - 2. Fire alarm system.
- Q. The equipment supplier shall document the performance of his equipment.
- R. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- S. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
- T. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

3.3 TESTING PREPARATION

- A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.4 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.5 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CxA.
- B. Fire Detection and Alarm System Testing: Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- C. Electrical Distribution System Testing: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested
- D. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Lighting Controls Testing and Acceptance Procedures: Testing requirements are specified in Division 26 lighting control Sections. Provide submittals and test data to the CxA.
2. Motor Controls Testing and Acceptance Procedures: Testing requirements are specified in Division 26 enclosed controllers Sections. Provide submittals and test data to the CxA.
3. Fire Alarm Testing and Acceptance Procedures: Testing requirements are specified in Division 28 fire alarm Sections. Provide submittals and test data to the CxA.
4. Coordination and functionality with the Building Automation System/Building Management Controls System
5. Access Control
6. Fire Alarm System
7. Grounding System
8. Lighting Controls
9. Panelboard
10. Power Distribution System
11. Power Monitoring/Metering System
12. Security System
13. Transformer

END OF SECTION 26 0800

SECTION 26 0913 - ELECTRICAL ENERGY METERING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes equipment and systems used to monitor and control electrical consumption:
 - 1. Multifunction meters.
 - 2. Raceways and boxes.
 - 3. Wires and cables.
 - 4. Identification.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Product Data submittals for multi-function meter equipment.
 - 2. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Solid state microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
 - 1. Electrical meters that monitor, control, and connect to the data transmission network.
 - 2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
- B. 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.
- C. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

- A. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.
- B. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
 - 1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), KWD, power factor.
 - 2. Communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.
- C. Backup Power Source:
 - 1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 MULTIFUNCTION ENERGY METERS

- A. Multifunction Energy Meter: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.
 - 1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
 - 2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.
- B. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - 1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of -20 to 70 degrees C and 5 to 95 percent relative humidity, noncondensing.
 - 2. Comply with IEC 60529 degree of protection code of IP65 for the front of the meter, and code of IP30 for the body.
- C. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- D. Accuracy:
 - 1. Comply with ANSI C12.20, Class 0.5.
 - 2. Neutral Current Measurement: Not more than 0.65 percent.
 - 3. Power Factor: 1.0 percent.
 - 4. Frequency: 0.1 percent.
 - 5. THD: 1.0 percent.
 - 6. Waveform Sampling: 64 per cycle.]

- E. Data Link:

1. To be compatible with building automation system.
- F. Meter Physical Characteristics:
1. Display: Backlit LCD with antiglare and scratch-resistant lens.
 2. Display of Metered Values:
 - a. One screen to show at least three user-selected values displayed at the same time. Selections available to display shall include the following:
 - 1) All meters.
 - 2) Measurements.
 - 3) THD.
 - 4) Energy.
 - 5) Demand.
 - 6) Minimum and maximum values.
 - 7) Power demand.
- G. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.
- H. Meters:
1. Instantaneous, rms:
 - a. Current: Each phase, neutral and three-phase average.
 - b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - c. Active Power (kW): Each phase and three-phase total.
 - d. Reactive Power (kVAR): Each phase and three-phase total.
 - e. Apparent Power (kVA): Each phase and three-phase total.
 - f. Power Factor: Each phase and three-phase total.
 2. Energy:
 - a. Active Energy (kWh): Three-phase total.
 3. Demand, Derived from Instantaneous rms Meters:
 - a. Current: Present and maximum.
 - b. Active: Present and maximum.
 - c. Reactive: Present and maximum.
 - d. Apparent: Present and maximum.
 4. Power Quality Measurements:
 - a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.
- I. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics shall be 150 mA at 200 V.
1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:
 - a. User-defined pulse output, associated with kWh.
 - b. User-defined pulse output, associated with kVARh.

J. Capacities and Characteristics:

1. Power Supply: 120-V ac, 60 Hz or low voltage DC.
2. Circuit Connections:
 - a. Voltage: Measurement autoranging, 60- to 400-V ac L-N. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
 - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
 - c. Frequency: 45 to 65 Hz.
 - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 RACEWAYS AND BOXES

- A. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

2.5 WIRES AND CABLES

- A. Electrical Power Wiring: Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
1. Copper conductors are Type THHN/THWN-2.
- B. Control Wiring:
1. Copper: Comply with requirements in metering and controls cut sheets or manuals.
- C. Balanced Twisted-Pair Cable: 100-ohm, four-pair balanced twisted-pair cable, Category 6.
- D. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
 2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
 3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

3.1 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.2 GROUNDING

- A. For data communication wiring, comply with NECA/BICSI 568.

- B. For low-voltage control wiring and cabling, comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:
 - 1. Visually inspect balanced twisted-pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test balanced twisted-pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- C. Wiring and cabling will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 26 0913

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SECTION 26 0923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Photoelectric switches.
2. Indoor occupancy switchbox-mounted occupancy and outdoor motion sensors.

B. Related Requirements:

1. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data

1.5 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

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

1. Douglas Lighting Controls
2. Intermatic, Inc.
3. Lighting Control and Design.
4. Lithonia Lighting; Acuity Lighting Group, Inc.

5. Novitas, Inc.
6. Paragon Electric Co.; Invensys Climate Controls.
7. Square D; Schneider Electric.
8. TORK.
9. Touch-Plate, Inc.
10. Watt Stopper (The).

- B. Description: Solid state, with dry contacts rated for 1800-VA tungsten or 1000-VA inductive to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

- C. Description: Solid state, with dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 30-second minimum, to prevent false operation.
3. Lightning Arrester: Air-gap type.
4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.2 INDOOR OCCUPANCY SENSORS

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

1. Hubbell Lighting.
2. Leviton Mfg. Company Inc.
3. Lighting Control and Design.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. nLight
6. ETC

- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

4. Sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.
 5. Sensors shall be rated for their environment. Sensors installed in damp environment not limited to shower rooms, locker rooms, outdoor areas, shall be provided with high humidity option. High humidity option shall be available by the manufacturer when required.
 6. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 7. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 8. Bypass Switch: Override the on function in case of sensor failure.
 9. Automatic Light-Level Sensor: Adjustable from 10 to 300 fc; keep lighting off when selected lighting level is present.
- C. Dual Technology Type: Ceiling mounting; detect occupancy by sensing a combination of passive infrared heat and ultrasonic technologies in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.3 SWITCH-BOX OCCUPANCY SENSORS

- A. Manufacturers:
1. Hubbell Lighting Inc.
 2. Leviton Mfg. Company Inc.
 3. Lighting Control and Design.
 4. nLight
- B. Description: PIR type with integral power-switching contacts rated for 800 W at 120-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/6-hp motors; and rated for 1000 W at 277-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/3-hp motors, minimum.
1. Sensor shall cover 1000 square feet for major motion and 300 square feet for minor motion.
 2. Sensor shall have an audible warning that beeps before lights turn off automatically. This feature shall have the option of being disabled.
 3. Include ground wire.
 4. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keeps lighting off when selected lighting level is present.
 5. Sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.

2.4 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No.14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve at least 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.
- B. Install ceiling mounted sensors in the center of the lay-in ceiling tile when available.
- C. Install power packs above the accessible ceiling at the light switch location in room. If room does not have accessible ceiling and the adjacent corridor does, then install on corridor side. Install power pack in junction box to conceal the termination if installed on an exposed ceiling.
- D. Install according to manufacturer's recommendations.

3.2 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch. All low voltage and communication cabling shall be run in conduit, refer to Section 26 0533 – Raceways and Boxes for Electrical Systems.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- D. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- F. 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 and UL 486B.

3.3 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify actuation of each sensor and adjust time delays.
- B. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.
- C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.5 ADJUSTING

- A. Adjust time delay on each sensor to 15 minutes unless noted otherwise on plans.
- B. Coordinate light sensor level with owner to determine preferred operating range.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

END OF SECTION 26 0923

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SECTION 26 2200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each product indicated.
- B. Shop Drawings: Indicate dimensions and weights.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces.
- B. Qualification Data: For testing agency.
- C. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Include dated documentation of torque values on all equipment.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.6 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Corporation; Cutler-Hammer.
 - 2. General Electric Company.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices, except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Must be TP-1 energy efficient compliant.
- C. Must be DOE 2016 compliant.
- D. Cores: One leg per phase.
- E. Enclosure: Ventilated, dripproof, NEMA 250, Type 2.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- G. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.

- H. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 - 2. Indicate value of K-factor on transformer nameplate.
- K. Wall Brackets: Manufacturer's standard brackets.
- L. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.
 - 1. Maximum acceptable sound level:
 - a. 9 KVA and less: 37dBA.
 - b. 30 to 50 KVA: 42 dBA.
 - c. 51 to 150 KVA: 47 dBA.
 - d. 151 to 300 KVA: 52 dBA.
 - e. 301 to 500 KVA: 57 dBA.
 - f. 501 to 750 KVA: 59 dBA.
 - g. 751 to 1000 KVA: 61 dBA.

2.4 CONTROL AND SIGNAL TRANSFORMERS

- A. Description: Self-cooled, two-winding dry type, rated for continuous duty, complying with NEMA ST 1, and listed and labeled as complying with UL 506.
- B. Ratings: Continuous duty. If rating is not indicated, provide at least 50 percent spare capacity above connected peak load.

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.
- B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

2.6 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls and floors for suitable mounting conditions where transformers will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
- B. Install floor-mounting transformers level on concrete bases. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
- C. Install transformers larger than 75 KVA at least 12 inches away from walls or other obstructions that might prevent free air circulation through and around the transformer.
- D. Identify transformers and install warning signs according to Division 26 Section "Identification for Electrical Systems".

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect transformer units to conduit system panelboards, disconnect switches, or junction/pull boxes, using liquid-tight flexible conduit.
- C. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."
- D. 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 and UL 486B.

3.4 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 5 percent. Submit recording and tap settings as test results.

- B. Adjust buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
- C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.5 FIELD QUALITY CONTROL

- A. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 2200

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SECTION 26 2416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Include evidence of NRTL listing for series rating of installed devices.
 - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 7. Include wiring diagrams for power, signal, and control wiring.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces.
- B. Field quality-control reports.
- C. Panelboard schedules for installation in panelboards.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Include dated documentation of torque values on all equipment.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.7 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.
- B. Prior to equipment installation, temporarily tape off distribution equipment rough-in and NEC clearance requirements in front of equipment and above equipment for other trades to observe. Label markings "ELECTRICAL CLEAR SPACE".

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
 - a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Div.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D Co.

2.2 FABRICATION AND FEATURES

- A. Enclosures: Flush- surface- mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
- B. Cabinet heights shall not exceed the following without pre-approval:
- C. (Subtract 12 inches from max cabinet height for MLO interiors)
- D.

1. NQ TYPE PANELBOARD MAIN	2. NUMBER OF SPACES	3. MAX CABINET HEIGHT
4. 100A or less MB	5. 30 spaces or less	6. 44 inches
7. 225A or less MB	8. 54 spaces or less	9. 50 inches
	10. 72 spaces or less	11. 56 inches
12. 400A or less MB	14. 42 spaces or less	15. 62 inches
	16. 72 spaces or less	17. 74 inches

18. NF TYPE PANELBOARD MAIN	19. NUMBER OF SPACES	20. MAX CABINET HEIGHT
21. 125A or less MB	22. 30 spaces or less	23. 44 inches
24. 250A or less MB	25. 54 spaces or less	26. 56 inches
27. 400A or less MB	28. 42 spaces or less	29. 68 inches
	30. 66 spaces or less	31. 86 inches

- E. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
- F. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
- G. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
- H. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.
- I. Breaker numbering: Provide adhesive labels with breaker numbering to be installed on each side of breakers to identify breaker number that corresponds to circuit directory.
- J. Bus: Hard-drawn copper, 98 percent conductivity.
- K. Main and Neutral Lugs: Mechanical type suitable for use with conductor material. Contractor is responsible for locating top or bottom feed main or lugs appropriate for top or bottom feeds.

- L. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
- M. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- N. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- O. Isolated Equipment Ground Bus: Where indicated on Drawings. Adequate for branch-circuit equipment ground conductors; insulated from box.
- P. Extra-Capacity Neutral Bus: Where indicated on Drawings. Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- Q. Feed-through Lugs: Where indicated on Drawings. Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- R. Provide handle clamps on all circuit breakers feeding fire alarm system components. Handle clamps shall lock the circuit breaker in the "ON" position.

2.3 PANELBOARD SHORT-CIRCUIT RATING

- A. Fully rated to interrupt symmetrical short-circuit current available at terminals with 20% additional capacity, 10,000 KA minimum, refer to plans.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Circuit breaker interrupting rating shall be 10,000 RMS symmetrical amperes at 120/208/240 volts; 14,000 RMS symmetrical amperes at 277/480 volts unless noted otherwise on plans (add 20% to rating on plans).

2.5 DISTRIBUTION PANELBOARDS

- A. Doors: Hinged, front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.
- B. Main Overcurrent Protective Devices: Circuit breaker similar characteristics to branch devices indicated below.
- C. Branch overcurrent protective devices shall be one of the following:
 - 1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
 - 2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

3. Circuit breaker interrupting rating shall be 22,000 RMS symmetrical amperes at 120/208/240 volts; 25,000 RMS symmetrical amperes at 277/480 volts unless noted otherwise on plans.
4. Fused switches.
5. For Circuit-Breakers Indicated on plans with "ET", provide electronic trip unit circuit breakers (ET) with the following settings:
 - a. RMS sensing; field-replaceable rating plug
 - b. 100% Sensing, 100% Rating for frame sizes of 400A and higher.
 - c. Instantaneous trip.
 - d. Long- and short-time pickup levels.
 - e. Long- and short-time time adjustments.
 - f. Ground-fault pickup level, time delay, and I^2t response,

2.6 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Electronic Trip Unit Circuit Breakers: (Where indicated on drawings and any over 400A) RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. 100% Rated with 100% sensing.
 - b. Instantaneous trip.
 - c. Long- and short-time pickup levels.
 - d. Long- and short-time time adjustments.
 - e. Ground-fault pickup level, time delay, and I^2t response.
 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 4. GFCI Circuit Breakers: Single- and two-pole configurations with 5 mA trip sensitivity.
 5. AFCI Circuit Breakers: Single- and two-pole configurations 20A trip, evaluated to UL 1699, Safety Standard for ARC-fault Circuit Interrupter.
- B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
 1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
 2. Ground-Fault Protection: Where indicated on Drawings. Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 3. Main breaker over 1000A at 480V on service entrance panel shall have ground fault protection.
 4. Breakers or trip devices with continuous trip setting adjustable to 1200A or higher shall be provided with remote arc energy reduction for maintenance option with remote switch to be installed near door of electrical room (where indicated on Drawings). Remote switch shall not require manual change in circuit breaker or trip device settings.
 5. Shunt Trip: Where indicated on Drawings. 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- C. Overcurrent protection devices installed into existing equipment.

1. Devices to have rating to meet or exceed the interrupting capacity short circuit rating of the panelboard.

2.7 CONTROLLERS

- A. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held general-purpose controller.
 1. Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 2. Control-Power Source: 120-V branch circuit.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Mounting Heights:
 1. Top of box 72 inches above finished floor, unless otherwise indicated.
 2. Bottom of box to be a minimum of 16 inches above finished floor.
- C. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- D. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Use a computer or typewriter to create directory; handwritten directories are not acceptable. All circuit loads shall be visible without removing directory card.
- E. Distribution Panel Circuit Breaker/Switch Identification: Label each circuit breaker/switch unit with laminated-plastic nameplate mounted with corrosion-resistant screws or permanent adhesive.
- F. Install filler plates in unused spaces.
- G. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- H. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.
- I. Provide AFCI breakers for all outlets indicated in 210.12.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
 - 1. Panel label to have white letters on a black background. Provide the panel name, voltage and panel fed from on label.
 - 2. Locate the label on the exterior of the panel door frame above the door unless otherwise indicated.
 - 3. Locate the label on the panel interior side of the door when panel is recessed and located in a finished space.
- C. Clearance Space: In electrical equipment rooms, mechanical rooms or janitor's closets, provide floor marking tape to indicate NEC required clear space in front of panelboards and distribution equipment. Provide floor label that reads "ELECTRICAL CLEAR SPACE". Provide floor tape and label in accordance with 260553, "Identification for Electrical Systems."

3.3 CONNECTIONS

- A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Where panelboards are located within 6 feet horizontally of any grounded structural building steel member, provide a bonding jumper between that steel member and the panelboard.
- C. 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 and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Ground-Fault Protection System Performance Testing: As required by NEC 230.95(C) for services at 1000A and higher, the ground-fault protection system shall be performance tested once installed.
 - 1. Testing shall be completed by a qualified person using primary current injection in accordance with instructions provided with the equipment.
 - 2. A written record of the testing shall be made and be available to the authority having jurisdiction.

- D. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
 - 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.
- E. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

3.5 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 2416

SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Wall-box motion sensors.
 - 3. Snap switches and wall-box dimmers.
 - 4. Communications outlets.

1.2 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Sample Finishes: Provide sample coverplate / device finishes of all available to interior designer for selection and final approval of device and coverplates throughout space. Colors may vary per space and per wall material device is to be installed on. Samples for any coverplates and devices include but are not limited to outlets, lighting controllers, data and AV coverplates fire alarm devices and exit signs.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Wiring Devices:
 - a. Cooper Wiring Devices
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Mfg. Company Inc.
 - d. Pass & Seymour/Legrand; Wiring Devices Div.

2.2 RECEPTACLES

A. Extra Heavy Duty/Industrial Grade Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, and UL 498.

1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".
2. Use in mechanical rooms, higher abuse areas, lab areas and rough service areas.

B. Tamper Resistant, Commercial Grade Straight-Blade Receptacles: Comply with NEMA WD 1, NEMA WD 6 and UL498.

1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".

C. GFCI Specification Grade Straight-Blade Receptacles: Feed-through type, comply with NEMA WD 6, UL498 and UL943. Must meet UL 2003 standards for diagnostic indication of miss-wiring, increased surge immunity, improved corrosion resistance and resistance to false tripping.

1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".
2. Use where indicated on drawings and breaker type GFCI protection is not provided and where access is restricted to facilities personnel.

D. Isolated Ground Straight-Blade Receptacles: Comply with NEMA WD 1, NEMA WD 6, UL498.

1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".
2. Use where indicated on drawings.

E. Controlled Receptacle

1. NEMA 5-20R configuration, 125V, 20 ampere, listed as "tamper resistant"
2. Must meet marking requirements indicating one or both halves of the receptacle are controlled.
3. Use where indicated on drawings
4. Refer to controlled receptacle wiring diagram detail provided in drawings.

2.3 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 - 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
 - 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.4 SWITCHES

- A. Single and Multi-pole Switches: Comply with UL20.
- B. Snap Switches: 20A, 120/277 volt, AC, heavy-duty grade, quiet type.
- C. Keyed Switches: 20A, 120/277 volt, AC, heavy-duty grade, quiet type.
 - 1. Provide two keys for each keyed switch installed on project. Turn-over keys to owner at time of Substantial Completion.

2.5 DEVICE PLATES

- A. Single and combination types to match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel. Color shall match device color.
 - 3. Material for Unfinished Spaces: Galvanized steel.. Color shall match wiring device color.
 - 4. Provide device plates for all power and data outlets.

2.6 WET LOCATION RECEPTACLE COVERS

- A. Wet Location Receptacle Covers: Receptacles located outdoors or those indicated as weatherproof shall be equipped with covers that maintain the NEMA 3R weatherproof integrity when attachment plug caps are inserted.
 - 1. Covers shall be die cast aluminum with powder coat finish, UL listed and comply with NEC.
 - 2. Covers shall be:
 - a. Tay Mac Corporation # MX3200
 - b. Red Dot #CKSUV

2.7 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartmentation: Barrier separates power and signal compartments.

- C. Housing Material: Stamped steel suitable for concrete installation.
- D. Power Receptacle: NEMA WD 6, Configuration 5-20R, ivory finish, unless otherwise indicated.
- E. Signal Outlet: Blank cover with bushed cable opening, unless otherwise indicated.
- F. Finish Trim and Door: Hinged nylon carpet/tile insert door permitting passage of cords and cables while in closed position. Trim color selected by Architect.

2.8 COMMUNICATIONS OUTLETS

A. Telephone Outlet:

- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
- 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3560-6.
 - b. Leviton; 40649.
- 3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1 complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:

- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
- 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3562.
 - b. Leviton; 40595.
- 3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.9 WIRING DEVICE AND COVER FINISHES

A. Stainless:

- 1. Covers to be stainless steel with white devices.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 - 1. Install devices and assemblies level, plumb, and secure.

2. Coordinate with device alignment detail, other trades and all rough-in so that devices are aligned, stacked and not offset per the device alignment detail rules. Stacking may be indicated on the plans, but where not indicated on plans, the devices shall be stacked as indicated on the alignment detail found on the architectural or electrical general sheet.
3. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
4. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
5. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
6. Install wiring devices after all wall preparation, including painting, is complete.
7. Provide box extension or use adjustable box in tile walls. Coordinate back box installation to be flush for lift off panels utilizing Z-clips so that the box can be adjusted or extended after the panel is set.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Provide an individual GFCI receptacle for each one shown on the drawings. Do not feed downstream receptacles on the same circuit using the protection of a GFCI receptacle.
11. Where GFCI receptacles are concealed behind either fixed or removable equipment, provide remote GFCI test device per NFPA-70 requirements.
12. Provide GFCI receptacles per NFPA-70 210.8 near sinks and within distance defined in NFPA (including through doors, cabinet doors or windows).
13. Provide GFCI receptacles where required by 210.8B in non-dwelling units.

14. Provide GFCI receptacles where required by equipment listed in 210.8D and 210.8E
15. Provide AFCI breakers for all outlets indicated in 210.12.
16. Provide GFCI receptacles for outlets serving HVAC equipment, electrical service areas and electrical equipment spaces or any other locations indicated per NFPA 210.63.

- E. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- F. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical. Group adjacent switches under single, multigang wall plates.
- G. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 CONNECTIONS

- A. Connect receptacles using screw-compression wiring contacts or pigtail leads. Do not use push-in contacts.
- B. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.
- C. Isolated-Ground Receptacles: Connect to isolated-ground conductor routed to designated isolated equipment ground terminal of electrical system.
- D. 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 and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.
- B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- C. Remove damaged and defective components.

3.5 CLEANING

- A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

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END OF SECTION 26 2726

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SECTION 26 2813 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Enclosed controllers.
 - b. Enclosed switches.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA FU 1 for cartridge fuses.
- C. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate fuse rating with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.6 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Ferraz Shawmut, Inc.
3. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC , time delay.
3. Type CD: 600-V, 31- to 60-A rating, 200 kAIC , time delay.
4. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
5. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
6. Type T: 250-V, zero- to 1200-A 600-V, zero- to 800-A rating, 200 kAIC , time delay.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Motor Branch Circuits: Class RK1, time delay.
- B. Other Branch Circuits: Class RK5, time delay.

3.3 INSTALLATION

- A. Install fuses in fusible devices as indicated. Arrange fuses so fuse ratings are readable without removing fuse.

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3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.

END OF SECTION 26 2813

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SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Enclosures.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For enclosed switches and circuit breakers.
1. Include plans, elevations, sections, details, and attachments to other work.
 2. Include wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Manual and Magnetic Enclosed Controllers:
 - a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
 - b. Eaton Corp.; Cutler-Hammer Products.
 - c. General Electrical Distribution & Control.
 - d. Rockwell Automation Allen-Bradley Co.; Industrial Control Group.
 - e. Siemens Energy & Automation, Inc.
 - f. Square D; a brand of Schneider Electric.
 - g. Industrial Electric Mfg.

2.2 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

- A. Type HD, Heavy Duty:
1. Three pole.
 2. 600-V ac.
 3. 1200 A and smaller.
 4. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
 5. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- B. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

2.4 NONFUSIBLE SWITCHES

- A. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
 4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

2.5 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

PART 3 - EXECUTION

3.1 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.

3.2 INSTALLATION

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Architect no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Indicate method of providing temporary electric service.
 - 3. Do not proceed with interruption of electric service without Architect's written permission.
 - 4. Comply with NFPA 70E.
- B. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- C. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- C. Perform tests and inspections.
- D. Tests and Inspections for Switches:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
 - e. Verify that fuse sizes and types match the Specifications and Drawings.
 - f. Verify that each fuse has adequate mechanical support and contact integrity.
 - g. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
 - h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
 - i. Verify correct phase barrier installation.
 - j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
 - 2. Electrical Tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
 - d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
 - e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."
- E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

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1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 2816

SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
 - 3. Submit test report data clearly demonstrating the maximum surge current rating has been tested on a COMPLETE SPD unit including all necessary fusing/overcurrent protection, thermal disconnects, integral disconnects and monitoring systems. Manufacturers who cannot provide this data will not be approved.

4. Submit data demonstrating that the SPD unit is capable of surviving the specified minimum repetitive surge current rating. The rating is based on surviving a specified number of ANSI/IEEE C62.41, Category C-High (10kA) impulses without failure or degradation in performance characteristics of more than 10%.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, acceptable manufacturers are as follows with no substitutions:
 1. Eaton Corporation.
 2. Schneider Electric Industries SAS.
 3. RayCap.

2.2 GENERAL SPD REQUIREMENTS

- A. SPD with 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 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be at least 125 percent of the nominal system voltage.

2.3 SERVICE ENTRANCE / ESSENTIAL LOCATION SUPPRESSOR

- A. SPDs: Comply with UL 1449, Type 2.
- B. The manufacturer shall provide a surge protective device that is classified by UL-1449 as a Type 2 device intended for installation on the load side of the main disconnect. The unit shall also be tested and listed to be installed as a 1-port (parallel) or 2-port device (In-line/Kelvin).
- C. SPD shall be rated for a 480Y/277 and 208Y/120 volt, 60 Hertz, 3-phase, 4-wire systems and shall be mounted externally to the main Distribution Power Panel, and connected in parallel to the power path through a dedicated circuit breaker.
- D. Nominal Current Discharge Level (I_n): The peak value of surge current through the SPD, selected by the manufacturer, having a current wave-shape of $8 \times 20 \mu s$ where the SPD remains functional after 15 surges shall be 20kA per mode.
- E. Impulse Current (I_{imp}): The service entrance device shall be capable of surviving direct strike transient ($10 \times 350 \mu s$) without failure or degradation of performance. Provide 3rd party test data confirming this, using minimum 12.5kA I_{imp} .
- F. Temporary Overvoltage (TOV) Survivability: The units shall be able to at a minimum survive 60 cycles (1s) of varying TOV levels.
- G. The service entrance SPD will be capable of surviving 600 IEC, $10 \times 350 \mu s$ waveforms of 5kA impulses without failure or degradation of original performance characteristics of more than 5%.
- H. Unit shall have a maximum surge current rating of 200,000 amperes L-N, 200,000 amperes L-G, and 200,000 amperes N-G, based on ANSI/IEEE C62.41 standard 8 by 20 microsecond current waveform.
- I. The SPD will be modular in design. Separate and replaceable suppression modules will protect each mode (L-N, L-G, and N-G).
- J. The system shall be constructed using multiple surge current diversion modules utilizing a single metal oxide varistor (MOV) and high capacity thermal electrode ensuring max surge current capacity can pass through the SPD without degradation or failure.

Service Entrance SPD Device Selection							
System Voltage	Switchboard Amps	SPD Model	Surge Rating	Protection Modes	Max Wire Size	Max Breaker Amps	Time Stamp Event Monitoring
208/120V Wye	Up to 2000A	120-3Y-N3-7-04-A-H	140kA/Mode	L-N, L-G, N-G	4/0	200	Yes
208/120V Wye	2000A-4000A	120-3Y-A1-7-04-A-H	200kA/Mode	L-N, L-G, N-G	4/0	200	Yes
480/277V Wye	Up to 2000A	277-3Y-N3-7-04-C-H	140kA/Mode	L-N, L-G, N-G	4/0	200	Yes
480/277V Wye	2000A-4000A	277-3Y-A1-7-04-C-H	200kA/Mode	L-N, L-G, N-G	4/0	200	Yes
480 Delta	Up to 2000A	480-3D-M3-3-04-D-H	140kA/Mode	L-G	#2 AWG	100	Yes
480 Delta	2000A-4000A	480-3D-N1-3-04-D-H	200kA/Mode	L-G	#2 AWG	100	Yes

PRODUCT DATA SHEET 1 - Unit shall provide maximum UL 1449, Voltage Protection Rating (VPR) as follows:

S', 'M', 'N' and 'A' are enclosure sizes; '1' = 80mm MOV; '3' = 40mm MOV		ANSI/UL 1449 4th Edition							
		Rayvoss Enclosure VPR							
		In-Line (Kelvin)				T-Connection (Parallel)			
Service Type	Enclosure	L-L	L-N	L-G	N-G	L-L	L-N	L-G	N-G
120 Single Phase	S3	X	1000	500	500	X	1200	800	700
	M1	X	900	500	500	X	1200	800	800
120/240 Split Phase	N3	900	900	600	700	1200	1200	700	700
	M1	900	900	500	500	1200	1200	800	800
120/208 Wye	N3	900	900	600	700	1200	1200	700	700
	A1	900	900	600	600	1200	1200	800	800
240 Delta	N3	1800	X	1000	X	2000	X	1200	X
	M1	1800	X	900	X	2000	X	1200	X
277/480 Wye	M3	2500	1200	1200	1200	2500	1500	1500	1500
	M1	1500	1200	1000	1000	2500	1500	1500	1200
480 Delta	M3	3000	X	1500	X	3000	X	1800	X
	M1	2500	X	1500	X	3000	X	1500	X

2.4 Non Service Entrance Rated

- A. The manufacturer shall provide a surge protective device that is classified by UL-1449, as a Type 1 or 2 device.
- B. SPD shall be rated for a 480Y/277 volt, 60 Hertz, 3-phase, 4-wire system and shall be mounted externally to the Distribution Power Panel, and connected in parallel to the power path through a dedicated circuit breaker.
- C. Nominal Current Discharge Level (I_n): The peak value of surge current through the SPD, selected by the manufacturer, having a current wave-shape of 8x20ms where the SPD remains functional after 15 surges shall be 20kA per mode.
- D. Quality: The manufacturer shall be ISO 9001 certified, demonstrating world-class quality systems for the design and manufacture of the SPD units.
- E. Unit shall be UL 1449, Most Recent Edition Listed. An SPD that is a UL "Recognized" component will not be accepted.
- F. Each surge suppression element (MOV) shall utilized a stacked MOV design.
- G. Unit shall provide maximum UL 1449, Voltage Protection Rating (VPR) for 208Y/120 Volt systems as follows:
 1. L-N = 600V
 2. L-G = 600V
 3. N-G = 600V
 4. L-L = 1000V
- H. Unit shall provide maximum UL 1449, Voltage Protection Rating (VPR) for 480Y/277 Volt systems as follows:
 1. L-N = 1000V
 2. L-G = 1200V
 3. N-G = 1200V
 4. L-L = 1800V

- I. Unit shall have a maximum surge current rating of 50,000 amperes or 100,000 amperes L-N, 50,000 amperes or 100,000 amperes L-G, and 50,000 amperes or 100,000 amperes N-G, based on ANSI/IEEE C62.41 standard 8 by 20 microsecond current waveform.
- J. Unit shall include dry contacts, LEDs, audible alarm, and a surge/TOV counter w/ time & date stamp.
- K. The SPD will be connected to the panelboard bus bar through a dedicated, minimum 30-amp breaker. Table below indicates acceptable breaker and wire ranges.

Branch Panel SPD Device Selection						
System Voltage	Switchboard Amps	SPD Model	Surge Rating	Protection Modes	Max Breaker Amps	Time Stamp Event Monitoring
208/120V Wye	Up to 400A	RSE-2-120-3Y-A-05-E-F-S	50kA/Mode	L-N, L-G, N-G	30-100	Yes
208/120V Wye	400A-2000A	RSE-2-120-3Y-A-10-E-F-S	100kA/Mode	L-N, L-G, N-G	60-125	Yes
480/277V Wye	Up to 400A	RSE-2-277-3Y-A-05-E-F-S	50kA/Mode	L-N, L-G, N-G	30-100	Yes
480/277V Wye	400A-2000A	RSE-2-277-3Y-A-10-E-F-S	100kA/Mode	L-N, L-G, N-G	60-125	Yes

- A. SPD with 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 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be at least 115 percent of the nominal system voltage.

2.5 SERVICE ENTRANCE SUPPRESSOR

- A. SPDs: Comply with UL 1449, Type 2.
- B. Raycap Rayvoss Series
- C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2
 - 1. SPDs with the following features and accessories:
 - a. Mounted externally to switchboard/panelboard, and fed by a dedicated circuit breaker.
 - b. Tested and certified to meet UL 3-cycle test, allowing SPD to coordinate with any breaker. SPD shall not require internal fusing protection.
 - c. Indicator light display for protection status.
 - d. Unit shall have a Form C summary alarm output contact rated for at least 1 amp at 120VAC for remote annunciation of SPD status.
 - e. Advanced monitoring, displayed through an integrated color LCD display, that includes real time measurements for voltage, current, frequency, power factor, kW, kVAR, kVA. The monitor should also include an event counter with time & date stamp, user settable alarm thresholds and an embedded web page for remote monitoring.
- D. Comply with UL 1283.

- E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per mode shall not be less than 140 kA. Surge rating shall conform to selection table and project drawings.
- F. The VPR Table above covers VPRs for various voltage configurations. DELETE this section and the next section.
- G. SCCR: Equal or exceed 200 kA.
- H. Inominal Rating: 20 kA.
- I. Enclosure: The unit shall at minimum have a heavy duty NEMA 12 dust-tight, drip-tight enclosure unless specified otherwise.
- J. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2
 - 1. SPDs with the following features and accessories:
 - a. Integral disconnect switch.
 - b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - c. Indicator light display for protection status.
 - d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
 - e. Surge counter.
- K. Comply with UL 1283.
- L. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- M. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 1200 V for 480Y/277 V.
 - 2. Line to Ground: 1200 V for 480Y/277 V.
 - 3. Line to Line: 2000 V for 480Y/277 V.
- N. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 700 V.
 - 2. Line to Ground: 1000 V.
 - 3. Line to Line: 1000 V.
- O. SCCR: Equal or exceed 100 kA.
- P. Inominal Rating: 20 kA.

2.6 PANEL SUPPRESSORS

- A. SPDs: Comply with UL 1449, Type 2.
 - 1. Include LED indicator lights for power and protection status.
 - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
- B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- C. Comply with UL 1283.
- D. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 700 V for 208Y/120 V.
 - 2. Line to Ground: 700 V for 208Y/120 V.
 - 3. Neutral to Ground: 700 V for 208Y/120 V.
 - 4. Line to Line: 1200 V for 208Y/120 V
- E. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 700 V.
 - 2. Line to Ground: 700 V.
 - 3. Neutral to Ground: 700 V.
 - 4. Line to Line: 1200 V.
- F. SCCR: Equal or exceed 100 kA.
- G. Inominal Rating: 20 kA.

2.7 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 4.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

2.8 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. SPD units shall be field installed externally to their respective branch circuit panelboard, distribution panel, motor control center or switchboard enclosure.
- C. Install devices at service entrance on load side with dedicated circuit breaker feed, with ground lead bonded to service entrance ground.
- D. Install conductors between suppressor and points of attachment as short and straight as possible. Desired lead length for phase and neutral conductors is 16 inches or less. In no case, shall the leads exceed 30 inches. Do not bond neutral and ground.
 - 1. Provide multipole, circuit breaker (size in accordance with manufacturer's recommendations) as a dedicated disconnect for the suppressor, unless otherwise indicated.
- E. After testing, disable or disconnect SPD unit until time of substantial completion. This is to eliminate deterioration of the unit during construction period.
- F. Wiring:
 - 1. Power Wiring: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. Controls: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 4313

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SECTION 26 5100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, LED modules and drivers.
2. Exit signs.
3. Lighting fixture supports.
4. Retrofit kits for LED lighting fixtures.

B. Related Sections:

1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 ACTION SUBMITTALS

- A. General: Some lighting fixtures may require at least 3 to 4 months of lead time. The Contractor is responsible for allowing sufficient time for the review process, manufacturing and delivery of these products. Substitutions will not be accepted on the basis of the Contractor's obligation to meet project completion deadlines.
- B. Lighting Fixtures Specified: The lighting fixtures specified in these documents have been carefully chosen for their ability to meet lighting requirements for this project. Selection has been based on esthetics, durability, ease of maintenance, luminance ratios, vertical and horizontal illuminances, lumen maintenance, CRI, efficacy, LED system life and warranty as well as their ability to satisfy governing codes such as the currently adopted version of ASHRAE/IES 90.1 for the state in which the project is being constructed.. The Contractor is cautioned that substitute products are likely to be unable to meet all of the same criteria as the product specified.
- C. Substitutions: When proposing substitute products, the Contractor shall be responsible for the negotiation with the Owner and Architect/Engineer, prior to substitution submittal, to assure fees are available to redesign the project based on the proposed substitutions or review by the Architect/Engineer of all photometric, sample, design and calculations for the proposed substitutions. All substitutions must be identified at time of bid. The Contractor's bid value shall not be based on substitutions in expectation of design team approval, nor on the Contractor's estimated value of the products specified. If review of the proposed substitute light fixtures finds the product unacceptable, the Contractor shall provide the fixtures specified at no additional cost to the Owner or delay in the project completion time.
- D. Product Data: For each type of lighting fixture and lamp indicated, arranged in order of fixture designation. Submit fixture data in bound brochure. Include illustrations and dimensions of fixtures, and showing photometric performance. Include data on features, accessories, and the following:
1. Contract Drawing light fixture type designation.

2. Dimensions of fixtures.
 3. Certified results of independent laboratory tests of fixtures and lamps for electrical ratings and photometric data.
 4. Emergency lighting unit battery and charger.
 5. LED fixture LM79, LM80 and TM21 testing data.
 6. Written Warranty Compliance
- E. Lighting Fixture Submittals: Fixture cuts lacking sufficient detail to indicate compliance with specifications will not be acceptable.
- F. Shop Drawings: Show details of nonstandard and custom fixtures. Indicate dimensions, weights, components, features, accessories, and methods of field assembly and mounting.
1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- G. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 01.

1.3 QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. Comply with LM 79, LM80 and TM21 LED testing standards.
- D. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.4 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.5 WARRANTY

- A. Special Warranty for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.
1. Special Warranty Period for Batteries: Manufacturer's standard 5 years from date of Substantial Completion. Full warranty shall apply for all 5 years.
- B. Warranty for LED fixtures: Written warranty, agreeing to replace drivers, LED modules and any fixture housing or components that fail in materials and workmanship within minimum (5) years from date of purchase. Warranty shall provide materials necessary to restore to acceptable operation. Labor shall be warranted for two years of the project substantial completion. The warranty shall include fixture

replacement or component replacement if the luminaire delivers less than 90% of the initial light level over the rated life.

1. For decorative pendant and track fixtures, warranty shall be minimum of (5) years.
2. All other fixtures shall match the standard warranty of the fixture specified.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURE MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 1. White Surfaces: 85 percent.
 2. Specular Surfaces: 83 percent.
 3. Diffusing Specular Surfaces: 75 percent.
 4. Laminated Silver Metallized Film: 90 percent.
- E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
 1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
 2. Lens Thickness: 0.125 inch (3 mm) minimum, unless greater thickness is indicated.
- F. Disconnecting Means: Provide disconnecting means for all LED fixtures. Disconnect shall comply with requirements in the applicable section(s) of NEC Article 410

2.3 LED FIXTURES

- A. GENERAL

1. LED light fixtures shall meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
2. LED light fixtures shall be sold as a complete system. Light fixtures shall have minimum efficacy as follows:
 - a. Linear Recessed LED (2x2,2x4,1x4,1x2): 95 Lumens per watt.
 - b. Linear Recessed LED (~4", Narrow Aperture): 74 Lumens per watt.
 - c. Linear Pendant LED (~4" Aperture): 95 Lumens per watt up, 74 Lumens per watt down.
 - d. Downlight LED: 80 Lumens per watt.
3. LED light fixtures shall have delivered lumen output within 5% of the delivered lumen output of the fixtures specified.
4. LED light fixtures shall be dimmable down to 20% or less of full output. If the specified fixture is dimmable to a level lower than 20%, equivalent fixture must be dimmable to the same level or lower than the fixture specified.
5. LED light fixture shall produce no noticeable variation in color temperature from one fixture to another by the same manufacturer. Color temperature shall be within 3-step MacAdam Ellipse.

B. LED DRIVERS

1. High performance LED driver to be 120/277V and wired for dimming or non-dimming. Provide with manufacturer tested compatible battery backup where indicated.
2. Driver expected lifetime shall be over 100,000 hours.
3. Total Harmonic Distortion Rating: Less than 20 percent.
4. Minimum power factor shall be 94%.

C. LED ENGINES

1. Manufacturers: Refer to light fixture schedule, light fixture is ordered as a complete system including LED driver, light engine and housing from the LED light fixture manufacturer.
2. LED Color Temperature and Minimum Color-Rendering Index:
 - a. Downlights: 4100 K and over 85 CRI
 - b. Linear LED: 4100 K and over 80 CRI
3. LED Life:
 - a. Downlights: Rated average shall be 50,000 hours rated per LM79, LM80 and TM-21 standards.
 - b. Linear LED: Rated average shall be 100,000 hours rated per LM79, LM80 and TM-21 standards.
 - c. Track and pendant heads: Rated average shall be 50,000 hours to 70% rated per LM79, LM80 and TM-21 standards.

2.4 EXIT SIGNS

A. General Requirements: Comply with UL 924 and the following:

1. Refer to Lighting Fixture Schedule on the plans.

B. Internally Lighted Signs: Features as follows:

1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.
- C. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 1. Battery: Sealed, maintenance-free, nickel-cadmium type.
 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 3. Operation: Relay automatically energizes lamp from unit when circuit voltage drops to 80 percent of nominal or below. When normal voltage is restored, relay disconnects lamps, and battery is automatically recharged and floated on charger.

2.5 FINISHES

- A. Fixtures: Manufacturer's standard, unless otherwise indicated.
 1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
 2. Metallic Finish: Corrosion resistant.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- H. Where applicable per NFPA70, 314.27C, provide ceiling fan type fan boxes in all habitable spaces where outlet boxes are used in the ceiling.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Interior Lighting Systems shall be installed in accordance with NECA/IESNA 500, Recommended Practice for Installing Indoor Commercial Lighting Systems and NECA/IESNA 502-2011, Recommended Practice for Installing Industrial Lighting Systems.
- B. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials.
- C. Support for Fixtures in or on Grid-Type Suspended Ceilings: Support fixture using grid plus the following:
 - 1. Fixtures shall be positively attached to the ceiling grid system.
 - 2. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners.
 - 3. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner.
 - 4. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently of panel, with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
- D. Suspended Fixture:
 - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with two separate stem hangers.
 - 3. Continuous Rows: Suspend from cable installed according to fixture manufacturer's written instructions and details on Drawings.
 - 4. Fixtures to be aligned and level, insure lenses are fastened properly in place.
 - 5. Any supports used to suspend fixture in exposed ceiling areas shall be installed as high as possible out of view and painted with ceiling.
 - 6. Mount remote type drivers out of site above ceilings or in painted enclosure.
 - 7. Coordinate installation so that no pipes, cable tray, duct work, etc are routed below light fixtures. Light fixtures shall be at a set plane so similar fixture types are all the same height or as noted on plans. Notify architects and engineers of any obstructions that will not allow for light to be installed at desired location.
- E. In Mechanical and Boiler Rooms, coordinate lighting fixture installation with mechanical piping, duct work, etc. Provide all required supporting rods and channel to bridge duct work and piping. Generally, mount fixtures 8-9 feet above floor unless noted otherwise. Avoid positioning above mechanical piping and ducts.

3.2 CONNECTIONS

- A. Ground equipment.
 - 1. Tighten electrical connections and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Provide instruments to make and record test results.
- C. Tests:
 - 1. Verify normal operation of each fixture after installation.
 - 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
 - 3. Verify normal transfer to battery source and retransfer to normal.
- D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units are acceptable.
- E. Corroded Fixtures: Replace during warranty period.

3.5 STARTUP SERVICE

- A. Burn-in all fixtures that require specific aging period to operate properly, prior to occupancy by Owner.

3.6 CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Fixture cones, reflectors, baffles, and visible trim shall be turned over to the owner clean and free of dust, drywall mud, smudges, fingerprints, and scratches. Only use methods and cleaning materials in accordance with respective fixture manufacturer recommendations.
- B. All adjustable light fixtures shall be aimed, focused and locked by the Contractor under the observation of the Architect/Engineer. When daylighting interferes with the aiming and focusing, aiming shall be accomplished during hours of darkness.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - 1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION 26 5100

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SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior luminaires with LED modules and drivers.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
 - a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
6. Photoelectric relays.
7. LED fixture compliance of lumen maintenance, CRI, efficacy and LED system rated life and warranty.
8. LED fixture LM79, LM80 and TM21 testing data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Manufactured pole foundations.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
4. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.
- D. LED fixture written warranty compliance.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

1.5 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. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 10 of each type and rating installed. Furnish at least one of each type.
 - 2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.6 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.
- B. 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.
- C. Comply with IEEE C2, "National Electrical Safety Code."
- D. Comply with NFPA 70.
- E. LED fixtures to be tested in compliance with LM79, LM80 and TM21 testing standards.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

- C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.
- D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
 - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.
 - 5. Warranty Period for LED fixtures: Minimum (5) years from date of Substantial Completion.
 - a. LED fixture warranty shall state agreement to replace LED drivers, LED light engine modules, fixture housing, components or accessories under the warranty coverage term.
 - b. Warranty shall include replacement of fixtures or components if the luminaire delivers less than 90% of the initial light level over the 100,000 hour life.
 - c. Fixture warranty to be extended to meet all requirements at a minimum of the warranty of the basis of design fixture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.

2.2 LUMINAIRES

- A. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- B. Metal Parts: Free from burrs, sharp corners, and edges.
- C. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

- D. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit servicing without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during servicing and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect driver when door opens.
- F. Exposed Hardware Material: Stainless steel.
- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- H. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- I. Fixture to be provided with all required accessories including (but not limited to) Luminaire, Arm or Mount, Pole, specified accessories.
- J. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor in luminaire doors.
- K. Photoelectric Relays: As follows:
 - 1. Contact Relays: Single throw, arranged to fail in the on position and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay.
 - 2. Relay Mounting: In luminaire housing.

2.3 LED LIGHT FIXTURES:

- A. Light fixtures shall be UL listed and meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
- B. Light fixtures shall be sold as a complete system. Light fixtures shall have a minimum efficacy of 75 lumens per watt or equal to that of the light fixture specified.
- C. Light fixtures shall have rated delivered lumen output within 5% of the rated delivered lumen output of the fixture specified.
- D. Light fixtures shall have accessible and replaceable drivers and LED light engine boards.
- E. LED drivers shall be 120/277V or 480V to match specified. LED drivers and light engines shall be Class 1 and have 100,000 hour rated life.
- F. Exterior fixtures to have one dimming driver per fixture head where dimming drivers are specified.
- G. LED driver Total Harmonic distortion shall be less than 20%.

- H. Light fixture minimum power factor shall be 90%.
- I. Light fixture color temperature shall be 4000K and minimum 90 CRI.
- J. Transient voltage surge suppression shall be 10kV integral to the fixture in accordance with IEEE/ANSI C62.41.2.
- K. Fixture shall be dark sky friendly.
- L. Fuses: One in each ungrounded supply conductor. Voltage and current ratings as recommended by ballast manufacturer. Fuses shall be installed in handhole near base of pole, not at fixture head.

2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
 - 1. Relay with locking-type receptacle shall comply with ANSI C136.10.
 - 2. Adjustable window slide for adjusting on-off set points.

2.5 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4-M.
 - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
 - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
 - 3. Anchor-Bolt Template: Plywood or steel.
- D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with

top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

- F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.6 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.
 - 1. Shape: Round, tapered.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 - 2. Finish: Same as luminaire.
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - a. Color: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.2 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
 - 1. Fire Hydrants and Storm Drainage Piping: 60 inches.
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 5 feet.
 - 3. Trees: 10 feet from tree trunk.
- C. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 - 1. Make holes 6 inches in diameter larger than pole diameter.
 - 2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
 - 3. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
 - 4. Cure concrete a minimum of 72 hours before performing work on pole.
- D. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.
- E. Raise and set poles using web fabric slings (not chain or cable).

3.3 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

- B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

3.5 FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged units.
- B. Advance Notice: Give dates and times for field tests.
- C. Provide instruments to make and record test results.
- D. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:
 - 1. Measure light intensities at night if specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
 - 2. Check intensity and uniformity of illumination.
 - 3. Check excessively noisy ballasts.
- E. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.
- F. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.6 CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.
- B. Adjust aimable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

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EXTERIOR LIGHTING
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SECTION 28 3100 - FIRE DETECTION AND ALARM

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. Failure to consult these documents shall not relieve the Contractor of the requirements therein.

1.2 SUMMARY

- A. This Section includes fire alarm systems with manual stations, detectors, signal equipment, controls, and devices.
- B. Architectural engineer shall provide general code compliant fire alarm layouts so that the contractor may reasonably estimate scope, cost and general rough-in requirements.
- C. Related Sections include the following:
 - 1. Division 08 Section "Door Hardware".

1.3 DEFINITIONS

- A. FACP: Fire alarm control panel.
- B. LED: Light-emitting diode.
- C. Definitions in NFPA 72 apply to fire alarm terms used in this Section.
- D. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

- A. General: Digital-addressable system with manual and automatic alarm initiation; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only.

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire alarm system design.

- b. Fire alarm certified by NICET, minimum Level III.
 - 2. Wiring Diagrams: Detail wiring and differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
 - 3. Battery: Sizing calculations.
 - 4. Floor Plans: Indicate final outlet locations and routings of raceway connections.
 - 5. Alarm Characteristics: Indicate the visual strobe candela and audible sound level requirements to satisfy NFPA 72 and the Authority having jurisdiction.
 - 6. Device Address List: Coordinate with final system programming.
 - 7. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
 - 8. Ductwork Coordination Drawings: Plans, sections, and elevations of ducts, drawn to scale and coordinating the installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, the detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
 - 9. Voice/Alarm Signaling Service: Equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
 - C. Operating Instructions: For mounting at the FACP.
 - D. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.
 - E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Comply with NFPA 72.
 - F. Maintenance Data: For fire alarm systems to include in maintenance manuals specified in Division 01. Comply with NFPA 72.
 - G. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 01 Section "Submittal Procedures," make an identical submission to authorities having jurisdiction. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.
 - H. Certificate of Completion: Comply with NFPA 72.
- 1.6 QUALITY ASSURANCE
- A. Installer Qualifications: An experienced installer who is a trained and certified representative of the FACP manufacturer for both installation and maintenance of units required for this Project.
 - B. Manufacturer Qualifications: A firm experienced in manufacturing systems similar to those indicated for this Project and with a record of successful in-service performance. Per the requirements of the local AHJ all of the following must be met.
 - 1. Manufacturer shall be responsible for layout of new and/or alterations to existing fire alarm equipment, specialties, and accessories, and repair and servicing of equipment shall be performed

only by a qualified installer experienced in such work; with a minimum of 5 previous projects similar in size and scope to this project; be familiar with all precautions required; and has complied with all the requirements of the authority having jurisdiction. Manufacturer shall provide all equipment required to meet the sequence of operations required by the code. Coordinate system design with architectural and mechanical systems including, but not limited to door holds, smoke dampers and duct detectors required for a code compliant system.

2. Manufacturer/installer shall follow project specifications and standards to provide a complete code compliant system installation. It is the general contractor or construction manager's responsibility to provide supervision to all subcontractors to ensure a proper installation according to the code and project specifications.
 3. Installer's responsibilities include designing, fabricating, and installing fire alarm systems and providing professional engineering services needed to assume engineering responsibility.
 4. Certifying Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a NICET Level III or IV certified layout technician.
- C. Source Limitations: Obtain fire alarm system components through one source from a single manufacturer.
- D. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.
- E. Comply with NFPA 72.

1.7 SEQUENCING AND SCHEDULING

- A. Existing Fire Alarm Equipment: Maintain fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire alarm equipment "NOT IN SERVICE" until removed from the building.
- B. Equipment Removal: After acceptance of the new fire alarm equipment, remove existing disconnected fire alarm equipment and restore damaged surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Notifier; a GE-Honeywell Company

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Control of System: By the FACP.

- B. System Supervision: Automatically detect and report open circuits, shorts, and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
- C. Priority of Signals: Automatic alarm response functions resulting from an alarm signal from one device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.
- D. Noninterference: A signal from one device shall not prevent the receipt of signals from other devices.
- E. System Reset: All devices are manually resettable from the FACP after initiating devices are restored to normal.
- F. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground or open circuit occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.
- G. Basic Alarm Performance Requirements: Unless otherwise indicated, operation of a manual station, or automatic alarm operation of a smoke or flame or heat detector initiates the following:
 - 1. Notification-appliance operation.
 - 2. Identification at the FACP and the remote annunciator of the device originating the alarm.
 - 3. Transmission of an alarm signal to the remote alarm receiving station.
 - 4. Unlocking of electric door locks in designated egress paths.
 - 5. Release of fire and smoke doors held open by magnetic door holders.
 - 6. Shutdown of fans and other air-handling equipment serving area when alarm was initiated.
 - 7. Closing of smoke dampers in air ducts of system serving area where alarm was initiated.
 - 8. Open normally closed contact tied to lighting control system to turn on emergency lighting.
 - 9. Recording of the event in the system memory.
- H. Alarm Silencing, System Reset and Indication: Controlled by switches in the FACP.
 - 1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
 - 2. Subsequent alarm signals from other devices reactivate notification appliances until silencing switch is operated again.
- I. Smoke detection for detectors with alarm verification initiates the following:
 - 1. Audible and visible indication of an "alarm verification" signal at the FACP.
 - 2. Activation of a listed and approved "alarm verification" sequence at the FACP and the detector.
 - 3. Recording of the event in the system memory.
 - 4. General alarm if the alarm is verified.
 - 5. Cancellation of the FACP indication and system reset if the alarm is not verified.
- J. Remote Detector Sensitivity Adjustment: Manipulation of controls at the FACP causes the selection of specific addressable smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory.

- K. Removal of an alarm-initiating device or a notification appliance initiates the following:
1. A "trouble" signal indication at the FACP and the annunciator for the device or zone involved.
 2. Recording of the event in the system memory.
 3. Transmission of trouble signal to remote alarm receiving station.

2.3 MANUAL PULL STATIONS

- A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
1. Double-action mechanism requires two actions, such as a push and a pull, to initiate an alarm. Break glass/plastic stations are not acceptable.
 2. Station Reset: Key or wrench operated; double pole, double throw; switch rated for the voltage and current at which it operates.
 3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false alarm operation.
 4. Integral Addressable Module: Arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.

2.4 SMOKE DETECTORS

- A. General: Include the following features:
1. Operating Voltage: 24-V dc, nominal.
 2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 3. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
 4. Integral Visual-Indicating Light: LED type. Indicates detector has operated.
 5. Sensitivity: Can be tested and adjusted in-place after installation.
 6. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
 7. Remote Controllability: Unless otherwise indicated, detectors are analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
- B. Photoelectric Smoke Detectors: Include the following features:
1. Sensor: LED or infrared light source with matching silicon-cell receiver.
 2. Detector Sensitivity: Between 2.5 and 3.5 percent/foot smoke obscuration when tested according to UL 268A.
 3. Integral Thermal Detector: Fixed-temperature type with 135 deg F setting.
- C. Duct Smoke Detector: Photoelectric type.
1. Photoelectric Smoke Detectors:

- a. Sensor: LED or infrared light source with matching silicon-cell receiver.
 - b. Detector Sensitivity: Between 2.5 and 3.5 percent/foot smoke obscuration when tested according to UL 268A.
2. UL 268A listed, operating at 24-V dc, nominal.
 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
 4. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring.
 5. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
 6. Integral Visual-Indicating Light: LED type. Indicating status. Provide remote status and alarm indicator and test station where indicated.
 7. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.
 8. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit. Motor shutdown wiring by Temperature Control Supplier.

2.5 NOTIFICATION APPLIANCES

- A. Description: Equip for mounting as indicated and have screw terminals for system connections.
 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.
- B. Chimes, High-Level Output: Vibrating type, 81 dB minimum rated output.
- C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Horns produce a sound-pressure level of 90 dB, measured 10 feet from the horn. White color.
- D. Visible Alarm Devices: Xenon strobe lights listed under UL 1971 with clear or nominal white polycarbonate lens. Mount lens on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch high letters on the lens. White color.
 1. Rated Light Output: 15, 30, 75, or 110 candela, as required to satisfy NFPA 72 requirements.
 2. Strobe Leads: Factory connected to screw terminals.
 3. Strobes shall be synchronized.
- E. Voice/Tone Speakers:
 1. High-Range Units: Rated 2 to 15 W.
 2. Low-Range Units: Rated 1 to 2 W.
 3. Mounting: Flush, semirecessed, surface, or surface-mounted; bi-directional as indicated.
 4. Matching Transformers: Tap range matched to the acoustical environment of the speaker location.

2.6 REMOTE DEVICE LOCATION-INDICATING LIGHTS AND IDENTIFICATION PLATES

- A. Description: LED indicating light near each smoke detector that may not be readily visible. Light is connected to flash when the associated device is in an alarm or trouble mode. Lamp is flush mounted in a single gang wall plate. A red, laminated, phenolic-resin identification plate at the indicating light identifies, in engraved white letters, device initiating the signal and room where the smoke detector or valve is located.

2.7 PROGRAMMER/TESTOR

- A. Provide a programmer/testor for any fire alarm system requiring such a device for programming and maintenance of signal initiation devices. Furnish unit complete with carrying case and instructions.

2.8 NOTIFICATION APPLIANCE CIRCUIT (NAC) EXTENDER PANELS

- A. Provide NAC panels as required to support notification appliances.
- B. Provide layout of proposed NAC panel locations prior to installation.

2.9 REMOTE ANNUNCIATOR

- A. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble indications. Also duplicate manual switching functions of the FACP, including acknowledging, silencing, reset, and test.
 - 1. Mounting: Flush cabinet, NEMA 250, Class 1.
- B. Display Type and Functional Performance: Alphanumeric display same as the FACP. Controls with associated LEDs permit acknowledging, silencing, resetting, and testing functions for alarm, supervisory, and trouble signals identical to those in the FACP.
- C. Where main FACP is installed in electrical room, remote annunciator panel shall be capable of making voice announcements.

2.10 EMERGENCY POWER SUPPLY

- A. General: Components include lead acid battery, charger, and an automatic transfer switch.
 - 1. Battery Nominal Life Expectancy: 20 years, minimum.
- B. Battery Capacity: Comply with NFPA 72.
- C. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.

- D. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.11 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module listed for use in providing a multiplex system address for listed fire and sprinkler alarm-initiating devices with normally open contacts.

2.12 WIRE

- A. Non-Power-Limited Circuits: Copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum.
- B. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer.

2.13 BREAKER LOCK DEVICE

- A. Provide breaker circuit lockout device on branch circuits feeding any fire alarm equipment including fire alarm panels and NAC panels. Utilize Elock fire alarm circuit lockout kit #ELOCK-FA and a red placard indicating "FIRE ALARM / EMERGENCY CIRCUIT INSIDE".

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Install fire alarm system in accordance with manufacturer's installation drawings and instructions.
- B. Connecting to Existing Equipment: Verify that existing fire alarm system is operational before making changes or connections.
 - 1. Connect new equipment to the existing control panel in the existing part of the building.
 - 2. Expand, modify, and supplement the existing control equipment as necessary to extend the existing control functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
- C. Manual Pull Stations: Mount semiflush in recessed back boxes.
- D. Ceiling-Mounted Smoke Detectors: Not less than 4 inches from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 30 feet apart in any direction.
- E. Wall-Mounted Smoke Detectors: At least 4 inches, but not more than 12 inches, below the ceiling.
- F. Smoke Detectors near Air Registers: Install no closer than 60 inches.

- G. Duct Smoke Detectors: Comply with manufacturer's written instructions.
 - 1. Verify that each unit is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - 2. Install sampling tubes so they extend the full width of the duct.
- H. Audible Alarm-Indicating Devices: Install chimes and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.
- I. Visible Alarm-Indicating Devices: Install adjacent to each alarm chime or alarm horn.
- J. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- K. Annunciator: Install with the top of the panel not more than 60 inches above the finished floor.
- L. Provide smoke detectors where required for all FACP and NAC panels.
- M. Provide power to all NAC panels. Connect to emergency power when available.

3.2 WIRING INSTALLATION

- A. Install wiring according to the following:
 - 1. NECA 1.
 - 2. TIA/EIA 568-A.
- B. Wiring Method:
 - 1. Install wiring in raceways except in accessible ceiling spaces and in gypsum-board partitions where cable wiring method may be used. Route the fire alarm cable in cable tray system when available. Wiring run in ceiling space where there is no tray or conduit, support independently of other systems with dedicated low voltage rings / hooks. No zip ties or support from other systems or conduits allowed.
 - 2. Conceal cables and raceways except in unfinished spaces.
 - 3. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 - 4. Fire-Rated Cables: Use of 2-hour fire-rated fire alarm cables, NFPA 70 Types MI and CI, is not permitted.
 - 5. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by the manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

- E. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- F. Provide handle clamps on all circuit breakers feeding fire alarm system components. Handle clamps shall lock the circuit breaker in the "ON" position.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals according to Division 26 Section Identification for Electrical Systems."
- B. Install instructions frame in a location visible from the FACP.
- C. Install circuit breaker lockout kit and placard on panels indicating where emergency fire alarm circuits are fed from.

3.4 GROUNDING

- A. Ground cable shields and equipment according to system manufacturer's written instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.
- C. Install grounding electrodes of type, size, location, and quantity as indicated. Comply with installation requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and connections and to supervise pretesting, testing, and adjustment of the system. Report results in writing.
- B. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.

- D. Final Test Notice: Provide a minimum of 10 days' notice in writing when the system is ready for final acceptance testing.
- E. Minimum System Tests: Test the system according to procedures outlined in NFPA 72. Minimum required tests are as follows:
 - 1. Verify the absence of unwanted voltages between circuit conductors and ground.
 - 2. Test all conductors for short circuits using an insulation-testing device.
 - 3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawings.
 - 4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
 - 5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
 - 6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
 - 7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications.
 - 8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.
- F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.
- H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.
- I. Provide certification of the fire alarm installation. Submit required documents to the Authority Having Jurisdiction.

3.6 CLEANING AND ADJUSTING

- A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 8 hours' training.
2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.8 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

END OF SECTION 28 3100