Specifications

HASTINGS MUSEUM
AIR HANDLER REPLACEMENT

Hastings, Nebraska

Construction Documents

2025 1723
July 2025

Alvine

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Project Specifications
Construction Documents

Alvine Engineering

Hastings Museum
Air Handler Replacement

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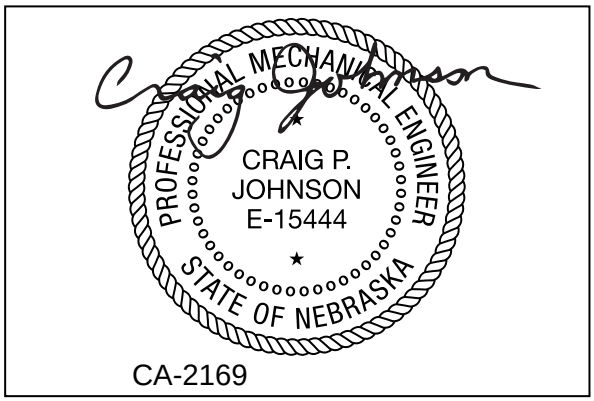

July 23, 2025

07/23/2025
I, Craig Johnson, am the Coordinating Professional for the Hastings Museum Air Handler Replacement project.

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GENERAL COMMISSIONING REQUIREMENTS

PART 1 GENERAL

1.1 COMMISSIONING AUTHORITY

A. The Commissioning Authority (CxA) has been contracted directly with the Owner for this project. The CxA has overall responsibility for planning and coordinating the commissioning process. However, commissioning involves all parties to the design and construction process, including the Contractor.

1.2 CONTRACTOR RESPONSIBILITY

A. This section of the specifications defines the Contractor's responsibilities with respect to the commissioning process. Each Contractor and subcontractor shall review this section and shall include in their bids for carrying out the work described, as it applies to each division and section of these specifications, individually and collectively.

1.3 DESCRIPTION OF WORK

A. The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the mechanical systems have been installed according to the Contract Documents and operate within the performance guidelines set out in the Basis of Design (BOD) document and these specifications. The CxA shall provide the Owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the Contract Documents.

B. Commissioning is intended to enhance the quality of system startup and aid in the orderly completion and transfer of systems for beneficial use by the Owner. The CxA shall be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers, and equipment suppliers.

C. The General Contractor, Mechanical Contractor, all mechanical subcontractors, and the Electrical Contractor shall be responsible for cooperating and coordinating their work with the CxA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems, and operating them during the commissioning process as required in this section.

D. Commissioning, including functional tests, O&M documentation review, and training is to occur after startup and initial checkout and be completed before Substantial Completion.

1.4 SCOPE OF COMMISSIONING

A. The following shall be commissioned:
   1. HVAC System, including:

a. Rooftop packaged DX units.
b. Ductwork and accessories.
c. Terminal units.
d. Building automation system.
e. Packaged air handling units.

2. Special Ventilation:
a. CO2-based demand controlled ventilation.

1.5 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including general and supplementary conditions, general mechanical provisions, and applicable mechanical and electrical specification sections, apply to work of this section.

B. Commissioning Plan.

1.6 REFERENCE STANDARDS

A. PECI (Samples) - Sample Forms for Prefunctional Checklists and Functional Performance Tests.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

A. Provide all standard testing equipment required to perform startup and initial checkout and required Functional Testing; unless otherwise noted such testing equipment will NOT become the property of Owner.

B. Calibration Tolerances: Provide testing equipment of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
1. Temperature Sensors and Digital Thermometers: Certified calibration within past year to accuracy of 0.5 degree F and resolution of plus/minus 0.1 degree F.
2. Pressure Sensors: Accuracy of plus/minus 2.0 percent of the value range being measured (not full range of meter), calibrated within the last year.
3. Calibration: According to the manufacturer's recommended intervals and when dropped or damaged; affix calibration tags or keep certificates readily available for inspection.

C. Equipment-Specific Tools: Where special testing equipment, tools, and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

D. Dataloggers: Independent equipment and software for monitoring flows, currents, status, pressures, etc. of equipment.
1. Dataloggers required to for Functional Tests will be provided by the CxA and will not become the property of Owner.

2.2 STARTUP, PREFUNCTIONAL CHECKLISTS, AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned, according to Article 1.04, Scope of Commissioning.

B. General: Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional performance testing for a given system shall be successfully completed prior to formal functional performance testing of equipment can begin.

C. Startup and Initial Checkout Plan: The primary role of the CxA in this process is to ensure there is written documentation that each of the manufacturer-recommended procedures has been completed.
   1. The subcontractor responsible for the purchase of the equipment develops the full startup plan by utilizing the manufacturer's detailed startup and checkout procedures from the O&M Manual and the normally used field checkout sheets. The plan shall 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.
   2. The full startup plan shall consist of something as simple as:
      a. The manufacturer's prefunctional checklists.
      b. The manufacturer's standard written startup procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
   3. The subcontractor submits the full startup plan to the General Contractor for review and scheduling.
   4. The CxA reviews the procedures and the format for documenting them, noting any procedures that need to be added. Checklists shall be submitted to CxA for approval not less than 8 weeks prior to startup.

D. Execution of Prefunctional Checklists and Startup: Contractor shall be responsible for filling out Prefunctional Checklists after completion of installation and before startup; witnessing by the CxA is not required unless otherwise specified.
   1. Each line item without deficiency is to be witnessed, initialed, and dated by the actual witness; checklists are not complete until all line items are initialed and dated complete with deficiencies.
   2. Checklists with incomplete items may be submitted for approval provided the Contractor attests that incomplete items do not preclude the performance of safe and reliable Functional Testing; resubmission of the checklist is required upon completion of remaining items.
   3. Individual checklists may contain line items that are the responsibility of more than one installer; Contractor shall assign responsibility to appropriate installers or subcontractors, with identification recorded on the form.
   4. If any checklist line item is not relevant, record reasons on the form.
   5. Regardless of these reporting requirements, Contractor shall be responsible for correct startup and operation.

6. Submit completed checklists to General Contractor within two days of completion. The General Contractor shall submit copies to the CxA for review.

E. Deficiencies: Correct deficiencies and reinspect or retest, as applicable, at no extra cost to the Owner.
   1. If difficulty in correction would delay progress, report deficiency to the CxA immediately.

2.3 FUNCTIONAL TESTS

A. A Functional Test is required for each item of equipment, system, or other assembly specified to be commissioned, unless sampling of multiple identical or near-identical units is allowed by the final test procedures.

B. Contractor shall be responsible for execution of required Functional Tests after completion of Prefunctional Checklist and before closeout.

C. Commissioning Authority shall be responsible for witnessing and reporting results of Functional Tests, including preparation and completion of forms for that purpose.

D. Contractor shall be responsible for correction of deficiencies and retesting at no extra cost to the Owner; if a deficiency is not corrected and retested immediately, the CxA shall document the deficiency and the Contractor's stated intentions regarding correction.
   1. Deficiencies are any condition in the installation or function of a component, piece of equipment, or system that is not in compliance with the Contract Documents or does not perform properly.
   2. Use the standard form provided with copies submitted to the Owner and Contractor.
   3. When the deficiency has been corrected, the Contractor shall complete the form certifying that the item is ready to be retested and shall return the form to the CxA; the CxA shall reschedule the test and the Contractor shall retest.
   4. Identical or Near-Identical Items: If 10 percent, or three, whichever is greater, of identical or near-identical items fail to perform due to material or manufacturing defect, all items will be considered defective; provide a proposal for correction within 1 week after notification of defect, including provision for testing sample installations prior to replacement of all items.
   5. Contractor shall bear the cost of Owner and CxA personnel time witnessing retesting.
   6. Contractor shall bear the cost of Owner and CxA personnel time witnessing retesting if the test failed due to failure to execute the relevant Prefunctional Checklist correctly; if the test failed for reasons that would not have been identified in the Prefunctional Checklist process, Contractor shall bear the cost of the second and subsequent retests.

E. Functional Test Procedures:
   1. Some test procedures are included in the Contract Documents. Where Functional Test procedures are not included in the Contract Documents, test procedures will be determined by the CxA with input by and coordination with the Contractor.

2. Examples of Functional Testing:
    a. Test the dynamic function and operation of equipment and systems (rather than just components) using manual (direct observation) or monitoring methods 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).
    b. 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.
    c. Systems are run through all the HVAC control system's sequences of operation, and components are verified to be responding as the sequences state.
    d. Traditional air or water test and balancing (TAB) is not Functional Testing; spot-checking of TAB by demonstration to the CxA is Functional Testing.
3. Samples of Functional Tests forms that indicate anticipated level of detail can be found in the Commissioning Plan.

F. Deferred Functional Tests: Some tests may need to be performed later, after Substantial Completion, due to partial occupancy, equipment, seasonal requirements, design, or other site conditions. Performance of these tests remains the Contractor's responsibility regardless of timing.

PART 3 EXECUTION

3.1 COMMISSIONING RESPONSIBILITIES - NON-CONTRACTOR TEAM MEMBERS

A. Introduction:
1. A multi-disciplinary team carries out commissioning. The commissioning responsibilities of some non-contractor team members during the construction and acceptance phases of the project are provided here for information and to provide some context for the overall process.

B. Commissioning Authority Responsibilities:
1. Plan, organize, and implement the commissioning process as specified herein.
2. Prepare the commissioning plan and ensure its distribution for review and comment.
3. Revise the commissioning plan as required during construction.
4. Chair commissioning meetings and prepare and distribute minutes to all commissioning team members, whether or not they attend the meeting.
5. In conjunction with the General Contractor, coordinate commissioning activities among all Contractors, sub-trades, and suppliers.
6. Monitor system verification checks and ensure the results are documented as the checks are done.
7. Monitor controls point-to-point checks done by the Controls Contractor and ensure the results are documented as the checks are done.
8. Observe equipment startups and initial system operations tests and checks, as appropriate.

9. Direct the Contractors to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes.
10. Witness all functional performance tests and document the results.
11. Prepare and submit a Commissioning Report which documents and checks and tests done throughout the commissioning process and the results obtained for each.
12. Ensure all required O&M Manuals, instructions, and demonstrations are provided to the Owner's designated staff.

C. Mechanical Engineer Responsibilities:
1. The Mechanical Engineer will review the Commissioning Plan and will participate, as appropriate, in on-site commissioning meetings.
2. During the acceptance phase of the commissioning process, the Mechanical Engineer may be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

D. Owner's Responsibilities:
1. The Owner will ensure the availability of operating staff for all scheduled instruction and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.
2. The Owner will also ensure the appropriate involvement of the Electrical Engineer, Architect, and any other consultants as required in the commissioning process.

3.2 COMMISSIONING RESPONSIBILITIES - GENERAL CONTRACTOR

A. The General Contractor has responsibility to ensure the overall completion of the work. In this regard, he shall:
1. Participate as required in the HVAC commissioning process.
2. Ensure the Mechanical Contractor performs all assigned HVAC commissioning responsibilities as specified in Article “Commissioning Responsibilities - Mechanical Contractor”.
3. Ensure the testing, adjusting, and balancing agency performs HVAC commissioning responsibilities as specified in Article “Commissioning Responsibilities - TAB Agency”, if TAB is contracted through the General Contractor.
4. Ensure the Electrical Contractor performs all assigned HVAC commissioning responsibilities as specified in Article “Commissioning Responsibilities - Electrical Contractor”.
5. Ensure the cooperation and participation in the HVAC commissioning process of all other subcontractors as applicable.

B. The General Contractor shall assign a representative to the commissioning team, and submit the person's name to the CxA within one month of the award of the contract. The representative shall have the authority to make decisions on behalf of the General Contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall facilitate communications among all Contractors and suppliers

and other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.

C. In the event that any scheduled equipment or system startups or functional performance tests are terminated because the CxA or Mechanical Engineer discover deficient or incomplete work, or due to non-attendance of required Contractor or supplier personnel, the Contractor or subcontractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses for any or all of the following representatives who were physically present for the purpose of witnessing the start or function performance tests: the CxA, the Mechanical Engineer, the Electrical Engineer, and the Owner. The Owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expense costs.

3.3 COMMISSIONING RESPONSIBILITIES - MECHANICAL CONTRACTOR

A. The Mechanical Contractor, and all mechanical subcontractors and suppliers, shall cooperate with the CxA and other commissioning team members to facilitate the successful completion of the commissioning process.

B. The Contractor shall assign a representative to the commissioning team, and submit the person's name to the CxA within one month of the award of the contract. The representative shall have the authority to make decisions on behalf of the Mechanical Contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall ensure communications between Mechanical Contractors and suppliers and all other commissioning team embers, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.

C. The Mechanical Contractor, and all mechanical subcontractors and suppliers, shall cooperate with the CxA in carrying out the HVAC commissioning process. In this context, the Mechanical Contractor shall:

1. Each Contractor and subcontractor shall include in their quotes the cost of participating in the commissioning process as specified herein.
2. Ensure the Temperature Controls Contractor performs HVAC commissioning responsibilities as listed in Article “Commissioning Responsibilities - Controls Contractor”.
3. Ensure the testing, adjusting, and balancing agency performs HVAC commissioning responsibilities as specified in Article "Commissioning Responsibilities - TAB Agency, if TAB is contracted through the Mechanical Contractor.
4. Ensure cooperation and participation of specialty subcontractors such as sheet metal, piping, refrigeration, and water treatment as applicable.
5. Ensure participation of major equipment manufacturers in appropriate startup, testing, and training activities.
6. Attend HVAC commissioning meetings scheduled by the CxA.

7. Notify the CxA a minimum of two weeks in advance of scheduled equipment and system startups, so the CxA may witness system verifications and equipment and system startups.
8. Provide sufficient personnel to assist the CxA as required during system verification and functional performance testing.
9. Prior to startup, inspect, check, and confirm the correct and complete installation of all equipment and systems for which system verification checklists are included in the Commissioning Plan. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and recheck until the results are satisfactory and the system is ready for safe startup.
10. Notify the CxA a minimum of two weeks in advance of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
11. Provide equipment and systems startup resources as specified and required. If, during an attempted equipment or system startup, deficient or incomplete work is discovered that would preclude safe operation, the startup shall be aborted until corrective action has been taken. Ensure such action is taken and verified before rescheduling a new startup. Those responsible for deficient or incomplete work shall be responsible for costs in accordance with this Section.
12. Carry out performance checks to ensure that all equipment and systems are fully functional and ready for the CxA to witness formal functional performance tests.
13. Operate equipment and systems for functional performance tests in accordance with the Commissioning Plan and as directed by the CxA. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the functional performance tests will be stopped by the CxA. Those responsible for deficient or incomplete work shall be responsible for costs in accordance with this Section. Ensure that all corrections necessary for full and complete system operation as specified are complete then, with the Temperature Controls Contractor and other applicable subcontractors, carry out functional performance checks to confirm correct operation before applying to the CxA to reschedule the functional performance tests for the system in question.
14. Prepare preliminary schedule for mechanical system orientation and inspections, O&M Manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start TAB, and task completion for use by the CxA. Update schedule as appropriate throughout the construction period.
15. Provide written notification to the General Contractor and CxA that the following work has been completed in accordance with the Contract Documents and the equipment, systems, and subsystems are operating as required.
    a. HVAC equipment including all fans, air handling units, dehumidification units, ductwork, dampers, terminals, and all mechanical equipment.
    b. Refrigeration equipment, pumping systems, and heat rejection equipment.
    c. Fire stopping in fire-rated construction, including fire and smoke damper installation, caulking, gasketing, and sealing of smoke barriers.
16. Provide a complete set of as-built drawings and O&M Manuals to the CxA.

3.4 COMMISSIONING RESPONSIBILITIES - TAB AGENCY

A. With respect to HVAC commissioning, the TAB agency shall:

1. Include costs for HVAC commissioning requirements in the quoted price.
2. Attend commissioning meetings scheduled by the CxA prior to, and during, on-site TAB work being done.
3. Submit proposed TAB procedures to the CxA and Mechanical Engineer for review and acceptance.
4. Attend the TAB planning meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC system.
5. At the completion of the TAB work, submit the final TAB Report to the General Contractor, with copies to the Owner, CxA, and Mechanical Engineer.
6. Participate in verification of the TAB Report by the CxA for verification or diagnostic purposes. This will consist of repeating a sample (normally 10 percent to 20 percent) of the measurements contained in the TAB Report as directed by the CxA.
7. Participate in O&M personnel training sessions as scheduled by the CxA.

3.5 COMMISSIONING RESPONSIBILITIES - CONTROLS CONTRACTOR

A. With respect to HVAC commissioning, the Controls Contractor shall:
1. Include cost for commissioning requirements in the quoted price.
2. Attend commissioning meetings scheduled by the CxA.
3. Provide the following submittals to the CxA for review:
   a. Hardware and software submittals.
   b. Control panel construction shop drawings.
   c. Diagrams showing all control points, sensor locations, point names, actuators, controllers and, where necessary, points of access, all superimposed on diagrams of the physical equipment.
   d. Narrative description of all control sequences for each piece of equipment controlled. These shall be provided to the CxA in electronic format upon request.
   e. Logic diagrams showing the logic flow of all control sequences.
   f. A list of all control points, including analog inputs, analog outputs, digital inputs, and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
   g. A complete control language program listing including all software routines employed in operating the control system. Also provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and functions of each routine and subroutine. It should also explain individual math or logic operations that are not clear from reading the software listing.
   h. Hardware O&M Manuals.
   i. Application software and project applications code manuals.
4. Inspect, check, and confirm the proper installation and performance of controls/BAS hardware and software provided by others.
5. Integrate installation and programming scheduling with construction and commissioning schedules.
6. Inspect, check, and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.

7. Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the Commissioning Plan.
8. In conjunction with the Mechanical Contractor, demonstrate system performance to the CxA including all modes of system operation (e.g. occupied, unoccupied, emergency) during the functional performance tests. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the functional performance tests will be stopped by the CxA. Those responsible for deficient or incomplete work will be responsible for costs in accordance with this Section.
9. Provide control system technician to assist during system verification and functional performance testing.
10. Provide support and coordination with TAB Contractor on all interfaces between controls and TAB scopes of work. Provide, at no additional cost to the TAB and CxA, all devices, such as portable operator's terminals and all software for the TAB agency to use in completing TAB procedures.

3.6 COMMISSIONING RESPONSIBILITIES - ELECTRICAL CONTRACTOR

A. With respect to HVAC commissioning, the Electrical Contractor shall:
1. Include cost for HVAC commissioning requirements in the quoted price.
2. Review design with respect to providing power to the HVAC equipment.
   a. Verify that proper hardware specifications exist for functional performance and sequence of operation required by specification.
   b. Verify that proper safeties and interlocks are included in the design of electrical connections for HVAC equipment.
3. Attend commissioning meetings scheduled by the CxA.
4. Schedule work so that required electrical installations are completed and systems verification checks and functional performance tests can be carried out on schedule.
5. Attend HVAC commissioning meetings scheduled by the CxA.
6. Inspect, check, and confirm in writing the proper installation and performance of all electrical services provided.'
7. Provide electrical system technicians to assist during system verification and functional performance testing as required by the CxA.

3.7 TEST PROCEDURES - GENERAL

A. Provide skilled technicians to execute starting of equipment and to execute the Functional Tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

B. Provide all necessary materials and system modifications required to produce the flows, pressures, temperatures, and conditions necessary to execute the test according to the specified conditions. At completion of the test, return all affected equipment and systems to their pre-test condition.

C. Sampling: Where Functional Testing of fewer than the total number of multiple identical or near-identical items is explicitly permitted, perform sampling as follows:
   1. Identical Units: Defined as units with same application and sequence of operation; only minor size or capacity difference.
   2. Sampling is not allowed for:
      a. Major equipment.
      b. Life-safety-critical equipment.
      c. Prefunctional Checklist execution.
   3. 30_____ = the percent of the group of identical equipment to be included in each sample; defined for specific type of equipment.
   4. 100_____ = the percent of the sample that if failed will require another sample to be tested; defined for specific type of equipment.
   5. Randomly test at least 30_____ percent of each group of identical equipment, but not less than three units. This constitutes the "first sample."
   6. If 10_____ percent of the units in the first sample fail, test another 10_____ percent of the remaining identical units.
   7. If 10 _____percent of the units in the second sample fail, test all remaining identical units.
   8. If frequent failures occur, resulting in more troubleshooting than testing, the Commissioning Authority may stop the testing and require Contractor to perform and document a checkout of the remaining units prior to continuing testing.

D. Manual Testing: Use 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”).

E. Simulating Conditions: Artificially create the necessary condition for the purpose of testing the response of a system; for example apply hot air to a space sensor using a hair dryer to see the response in a VAV box.

F. Simulating Signals: Disconnect the sensor and use a signal generator to send an amperage, resistance, or pressure to the transducer and control system to simulate the sensor value.

G. Over-Writing Values: Change the sensor value known to the control system in the control system to see the response of the system; for example, change the outside air temperature value from 50 degrees F to 75 degrees F to verify economizer operation.

H. Indirect Indicators: Remote indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100 percent closed, are considered indirect indicators.

I. Monitoring: Record parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of the relevant control systems; where monitoring of specific points is called for in Functional Test Procedures:
   1. All points that are monitored by the relevant control system shall be trended by Contractor; at the CxA’s request, Contractor shall trend up to 20 percent more points than specified at no extra charge.
   2. Other points will be monitored by the CxA using dataloggers.

3. At the option of the CxA, some control system monitoring may be replaced with datalogger monitoring.
4. Provide hard copies of monitored data in columnar format with time down left column and at least 5 columns of point values on same page.
5. Graphical output is desirable and is required for all output if the system can produce it.
6. Monitoring may be used to augment manual testing.

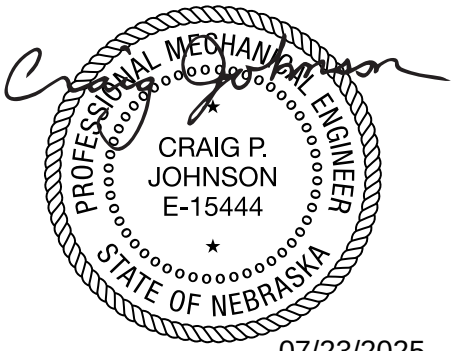
3.8 OPERATION AND MAINTENANCE MANUALS

A. See mechanical specification Section "General Mechanical Requirements".

B. Submit manuals related to items that were commissioned to CxA for review; make changes recommended by CxA.

C. Commissioning Authority will add commissioning records to manuals after submission to Owner.

END OF SECTION



CA-2169 07/23/2025

SECTION 23 04 00

COMMON REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes basic materials and methods to complement other Division 23 Sections.

1.2 WARRANTIES

A. Warrant all materials, workmanship and equipment against defects for a period of one year after the date of substantial completion.

B. Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those divisions of the Project Manual.

C. Repair or replace, at no additional cost to the Owner, any item which may become defective within the warrant period.
   1. Repair or replacement of compressorized equipment shall include a complete refrigerant charge.

D. Any manufacturers' warranties concerning any item installed will run to the benefit of the Owner.

E. The Contractor agrees not to void or impair, or to allow Sub-Contractors to void or impair, any warranties regarding products or items installed as part of this project.

F. The repair of faulty workmanship shall be considered to be included in the contract.

1.3 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

A. If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Engineer for clarification.

B. Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date.

C. Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.

D. When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.

E. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.4 CONTRACT DOCUMENT DISCREPANCIES

A. If any ambiguities should appear in the contract documents, request clarification from the Engineer before proceeding with the work.

B. If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Engineer.

C. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Engineer was requested and obtained before submission of proposed methods or materials.

D. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 DEFINITIONS

A. The following definitions shall apply throughout the contract documents:
1. Engineer: Architect or Engineer
2. Code: All applicable national, state and local code
3. Mechanical: All plumbing, HVAC, & fire protection work required by the Contract Documents
4. Electrical: All electrical and fire alarm work required by the Contract Documents
5. Contractor: Any Contractor performing work required by the Contract Documents
6. Indicated: Shown on drawings, noted, scheduled or specified
7. Selected: Selected by the Architect or Engineer
8. Provide: Furnish, install, connect and tested complete and ready for use
9. Furnish: Supply and deliver to the site ready for installation
10. Install: Install complete, per Contract Documents and manufacturer's requirements.
11. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
12. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
13. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
14. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
15. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
16. Dry Locations: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

17. Damp Locations: Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture.
    a. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold storage warehouses.
18. Wet Locations: Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.

1.6 SYMBOLS

A. Items of equipment and materials are indicated on the drawings in accordance with the symbols shown on the plans.

1.7 ABBREVIATIONS

A. Refer to abbreviations list shown on the Drawings.

1.8 CODES

A. The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards.

B. All work shall conform to all applicable sections of currently adopted editions of the following codes, standards, and specifications:
1. International Building Code (IBC)
2. International Fire Code (IFC)
3. International Energy Conservation Code (IECC)
4. International Fuel Gas Code (IFGC)
5. Uniform Plumbing Code(UPC)
6. International Mechanical Code (IMC)
7. Safety and Health Regulations for Construction
8. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards
9. National Electrical Code (NEC)
10. National Fire Protection Association (NFPA)
11. Life Safety Code (NFPA 101)
12. Factory Mutual Global Engineering (FMG)
13. American Gas Association (AGA)
14. Underwriters' Laboratories, Inc. (UL)
15. National Electrical Safety Code (NESC)
16. All applicable national, state and local codes and amendments.

1.9 PERMITS

A. The Contractors shall familiarize themselves with all requirements regarding all permits, fees, etc., and shall comply with them.

B. All permits, licenses, inspections and arrangements required for the work shall be obtained by the Contractor at his expense.

C. All utilities shall be installed in accordance with the local rules and regulations and all charges shall be paid by the Contractor.

1.10 CODE COMPLIANCE

A. Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that indicated shall not be substituted.

B. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of systems. Wherever practical, install systems as indicated.

C. Where the National Electrical Code or applicable codes require controllers to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment.

1.11 MATERIALS AND EQUIPMENT MANUFACTURERS

A. Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.

B. Materials and equipment shall be provided in accordance with the following:
   1. Primary Design Products: Primary design products are those products around which the project was designed in terms of capacity, performance, physical size and quality.
   2. Primary design products are indicated by use of a single manufacturer's name, model number or similar data on drawings or schedules or within the specifications.
   3. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
   4. Acceptable Equivalent Substitutions: Acceptable equivalent substitutions are products of manufactures other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements:
      a. The product shall be manufactured by one of the acceptable manufacturers listed in the Project Manual, drawings, or addenda.
      b. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
      c. The Contractor providing the substitution shall bear the total cost of all changes due to substitutions. These costs may include additional compensation to the Engineer for redesign and evaluation services,

increased cost of work by the Owner or other Contractors, and similar considerations.

d. Performance Requirements: Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.

e. Compliance with Standards, Codes and Regulations: Where the specifications require only compliance with an imposed standard, code or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes and regulations.

f. Proposed substitutions will be judged on the basis of quality, performance, appearance and on the governing space limitations. The reputation of the manufacturer, delivery time requirements, and the availability of repair or replacement parts may also be considered.

g. The Engineer shall be the sole and final judge as to the suitability of substitution items.

1.12 SUBMITTALS

A. Shop Drawings, Product Data and Samples:

1. Other section in the Project Manual shall be adhered to if more stringent than the following paragraphs.
2. When required by other sections of this Project Manual, submit shop drawings, product data or samples to the Engineer for review.
3. Submittals deemed unnecessary by the Engineer shall be returned indicating “No Action Taken”.
4. A completed copy of the transmittal form included with the Project Manual shall accompany each submittal.
5. Submittals shall be labeled indicating the specification number and title, shop drawing or product data description and the respective Part 2 paragraph and sub-paragraph numbers.
6. Submittals not listed in the Project manual shall reference the respective contract document.
7. Unless otherwise noted, submit one copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.
   a. Shop drawings and product data shall be in original searchable PDF format.
8. Shop drawings are drawings, diagrams, schedules and other data specifically prepared for this project by the Contractor, Manufacturer, Supplier, or Distributor to illustrate some portion of the work. Shop Drawings shall also detail fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.
   a. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.
9. Product data are illustrations, standard schedules, performance charts, instruction brochures, diagrams and other information furnished by the

Contractor, Manufacturer, Supplier, or Distributor to illustrate a material, product or system for some portion of the work.

10. All submittals shall clearly indicate proposed items, capacities, characteristics and details in conformance with contract documents. All equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions and special features required shall be certified by the manufacturer.
11. Submittals shall indicate manufacturer's delivery time for the item after review by the Engineer.
12. The Engineer shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
13. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Engineer's review of shop drawings, product data or samples.
14. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Engineer's review of those drawings.

B. Operation and Maintenance Manuals:
   1. Prepare electronic operation and maintenance manuals for the equipment furnished.
   2. The manual shall be in original searchable PDF format with equipment organized by specification section. Bookmarking shall be provided in the PDF for each specification section and piece of equipment.
   3. Manuals shall be submitted to the Engineer for review and distribution to the Owner not less than 30 days prior to substantial completion of the project.
   4. Manuals not meeting the requirements of this section may be rejected by the Engineer.
   5. Manual shall include, but shall not be limited to, the following:
      a. A cover page including:
         1) Project name and address
         2) Division of work covered by the manual
         3) Name, address and telephone number of Contractor and all Sub-Contractors including night or emergency numbers
      b. A Complete Index. Contractor may submit the index to the Engineer for review prior to submittal of complete manuals if desired.
      c. Manufacturer's equipment product data O&M manuals and parts lists identified by the equipment mark used in the contract drawings.
      d. Names, Addresses and Telephone Numbers. This list shall include the manufacturer and local representative who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the manual.
      e. Startup, Operation and Shutdown Procedures. Provide a written description of procedures for startup, operation and shutdown of each item or system. This description shall include motors to start, valves to open, etc., in proper sequence, and the location of switches, starters, pushbuttons and valves. Description shall include item references or

labels used in the contract documents unless otherwise instructed in advance by the Owner.

f. Seasonal Changeover Procedure. Provide a written description of the procedure for necessary seasonable changeover from heating to cooling and vice versa.

g. Equipment Accessory Schedule. Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required and the manufacturer of all renewable items.

h. Lubrication Schedule. Provide a chart listing each piece of equipment, the proper type of oil or grease required, and recommended frequency of lubrication.

i. Emergency Procedures. Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.

j. One copy of all shop drawings.

k. Signed letters of certification of inspection and similar information.

l. All manufacturers' warranty information.

m. Provide documentation that training was performed for each item specified to include Owner training. Include name of Owner’s representative(s) present, date and time of training.

n. Normal Maintenance Schedule. Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days and yearly.

o. Provide documentation that Extra Materials were received by the Owner for each section requiring Extra Materials.

p. Motor List. The list shall indicate motor location, equipment served (using labels indicated on drawings), horsepower, electrical characteristics, motor type, and rpm. Motors less than 1/2 horsepower need not be included.

1.13 OPERATING TRAINING

A. Complete operating instructions for each system and item of equipment shall be provided to the Owner's designated personnel.

B. Operation and Maintenance Manuals must be reviewed and accepted by the Engineer and provided to the Owner prior to operating training.

C. Training shall be scheduled at the convenience of the Owner. A minimum of 4 hours, per system, of training shall be provided.

D. Training shall include instructions on the following:

1. Startup and shutdown procedures
2. Seasonal changeover
3. Periodic maintenance
4. Emergency operation
5. Safety

E. In addition to the instructions required above, wherever possible perform the operations being described in order to fully illustrate system operation.

F. At the completion of training, turn over to the Owner all required keys and special tools for installed equipment. Each key or tool shall be labeled with its use.

1.14 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, “Structural Welding Code-Steel”.

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications”.
   1. Comply with provisions in ASME B31 Series, “Code for Pressure Piping”.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.15 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.16 COORDINATION

A. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of systems. Wherever practical, install systems as indicated.

B. Provide offsets and elevation changes in piping, conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.

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

D. Coordinate arrangement, mounting, and support of 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.

E. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the installations that follow.
   1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

F. Sequence, coordinate, and integrate installing materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

G. Coordinate service connections to components furnished by utility companies.
   1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for metering components.
   2. Comply with requirements of authorities having jurisdiction and of utility company providing water, gas, electrical power and other services.

H. Coordinate location of access panels and doors for items that are concealed by finished surfaces.

I. Coordinate testing of items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.17 STRUCTURAL COORDINATION

A. In cases where the Contractor determines that superimposed loads such as suspended or floor mounted mechanical, electrical, plumbing system or equipment exist which exceed design loads indicated on structural contract documents, Contractor shall submit load data to Design Professionals for review prior to proceeding with work.

B. Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc. over the member's tributary area in a way that the design superimposed dead loads listed in structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required achieving the allowable load distribution.

C. Connections of systems designed by Contractor's engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for designing, furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

D. Coordinate locations of new fire suppression, plumbing and HVAC penetrations through existing structure and construction. Utilize all existing documentation of conditions for coordination. Verify penetrations utilizing GPR (Ground Penetrating Radar) as necessary to confirm penetration locations.

PART 2 - PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Specific Notes and/or Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 SHORT-CIRCUIT CURRENT RATING (SCCR) FOR EQUIPMENT AND ASSOCIATED CONTROL PANELS

A. SCCR Compliance - Equipment manufacturers and suppliers shall provide a certified SCCR for all equipment and associated panels to be provided with equipment procured under these specifications. The certified SCCR rating shall be no less than the value of the available fault current at the switchboard or panel serving the equipment as indicated on the Division 26 Electrical Riser Diagrams. Manufacturer shall provide internal components that meet or exceed the SCCR rating required by these specifications. Manufacturer shall refer to the National Electrical Code (NEC), which is also known as NFPA 70, Article 100 for additional requirements

B. Supplemental SCCR Compliance Data - At the manufactures option, they may calculate the available fault current at the specific equipment connection point. Manufacturer shall obtain feeder size, breaker type and length of feeder from the Division 26 contractor. All calculations shall be submitted as part of the equipment submittal for review by the engineer.

C. Application of Labels - All equipment and control panels associated with equipment procured under these specifications shall have a permanently installed label provided by the manufacturer as a part of the equipment indicating the SCCR rating of the equipment. Labels shall comply with NEC Article 409 - Industrial Control Panels, and NEC Article 670 - Industrial Machinery.

2.3 CONTROL SYSTEM INTERFACES

A. Equipment and systems shall be able to interface and integrate to BMCS systems and sequences via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.

B. System and Equipment to BMCS Interfaces shall be provided for, but not limited to:
1. Manufacturer's packaged system controllers and control panels.
2. Packaged rooftop air handling units.
3. Packaged split system air handling units.

2.4 MATERIALS

A. Unless otherwise specified, all materials and equipment shall be new, unused and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production.

2.5 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

A. Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.6 QUANTITY OF SPECIFIED ITEMS REQUIRED

A. Wherever in these specifications an article, device or piece of equipment is referred to in the singular number; such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

2.7 PIPE OR CONDUIT PENTERATION HOUSING & HOODS

A. Manufacturer:
   1. RPH; www.RoofPenetrationHousings.com

B. References:
   1. ICC-500, FEMA 320/361 – Third Party Tested to +225 mph
   2. ICC 2015 Energy Code – Third Party Tested to ASTM E 2078-13 Standard Test Method for Air Permeance of Building Materials
   3. ASTM E 1980 Solar Reflectance Index (SRI)
   4. FEMA P749 – Seismic Provisions

C. Lid and housing lined with insulation to a minimum value of R-19.

D. Warranty: 20 years.

E. Roof Mounted: Engineered penetration housing, accommodating up to 18 pipes/conduits-- cables, water, refrigeration, and power in one roof penetration with high rain tight integrity.

F. Roof penetration system is constructed of 14 gauge UV powder coated, welded, galvanized steel or aluminum with stainless steel hardware.
   1. Removable, gasketed lid to housing and housing to curb connection joints, pitched cover.
   2. Exit seal construction to be manufactured in all aluminum construction and 100% Sil-X-14 silicone gaskets.
   3. All seals must be protected from UV with an aluminum or stainless steel jacket.

G. Coordinate size of housing and hoods with all trades utilizing the penetration.

H. Furnish with 18-inch tall insulated curb and extensions for roof applications.

2.8 ROOF MOUNTED PIPE, DUCTWORK AND CONDUIT SUPPORT SYSTEMS

A. Manufactures:
   1. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com.
   2. Eaton, Dura-Blok.
   3. Erico International Corporation: www.erico.com.

4. PHP Systems/Design, www.phpsd.com
5. Unistrut, UNIpier.

B. Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
1. Bases: UV resistant material, molded polycarbonate resin, HDPE or rubber.
2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
3. Stut style, galvanized steel horizontal and vertical supports, attaching hardware.
4. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
5. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
6. Height: Provide minimum clearance of 18 inches under pipe to top of roofing.
a. Adjustable mounting height.
7. Operating temperature: -30F to 150F.

2.9 ELECTRICAL WIRE

A. All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.

B. All wiring running exposed in return air plenums shall be plenum-rated cable for fire and smoke spread.

2.10 LOW VOLTAGE CONTROL WIRE AND CABLE

A. All wiring materials section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.

B. Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC, and General Purpose Cabling:
1. Cable shall consist of copper conductors not less than #18 AWG stranded.
2. Cable shall be two- or three-conductor twisted cable with a drain wire.
3. Cable shall have a 100 percent overall shield.
4. Cable shall be plenum rated.
5. Cable shall meet or exceed NEC voltage rating of 300 volts.
6. Cable shall be NEC type CMP.
7. Cable shall meet or exceed UL temperature rating of +60 deg C.

C. Primary and Secondary Communications Network Cabling:
1. Cable shall be of type recommended by the DDC system manufacturer.
2. Cable shall be shielded.
3. Cable shall be plenum rated.
4. Cable shall meet or exceed NEC voltage rating of 150 volts.
5. Cable shall meet or exceed UL temperature rating of +60 deg C.

PART 3 - EXECUTION

3.1 GENERAL

A. Fabrication, erection, and installation of the complete mechanical system shall be done by qualified personnel experienced in such work and shall proceed in an orderly manner so as not to hold up the progress of the project.

B. The Contractor shall check all areas and surfaces where mechanical equipment or materials are to be installed and report any unsatisfactory conditions before starting work.

C. Commencement of work signifies the Contractor's acceptance of the conditions as fit and proper for the execution of the mechanical work.

D. Equipment and systems shall be installed in accordance with manufacturer's instructions, requirements, or recommendations.

3.2 DELIVERY AND STORAGE OF MATERIALS

A. Take provisions for the delivery and safe storage of materials and shall make the required arrangements with other Contractors for the introduction into the building of equipment too large to pass through finished openings.

B. Materials shall be delivered at such stages of the work as will expedite the work as a whole and shall be marked and stored in such a way as to be easily checked and inspected.

C. Contractor shall be responsible for adequately protecting all supplies and equipment during cold weather.

D. All items subject to cold weather damage shall be protected by covering, insulating, or storing in a heated space.

3.3 COOPERATION WITH OTHER CONTRACTORS

A. Perform the work in conformance with the construction called for by other trades and afford other Contractors reasonable opportunity for the execution of their work.

B. Properly connect and coordinate the mechanical work with the work of other Contractors at such time and in such a manner as not to delay or interfere with their work.

C. Examine the contract documents for the General, Mechanical, and Electrical work and the work of other trades. Coordinate work accordingly.

D. Promptly report to the Engineer any delay or difficulties encountered in the installation of the mechanical work which might prevent prompt and proper installation of work required from other trades.

E. Systems Test and Balance Contractors or personnel shall coordinate their work with the contractors who installed the systems being tested or balanced.

F. The Temperature Control Contractor or personnel shall be present during systems test and balance.

3.4 COORDINATION OF WORK

A. The list below is the precedence of assigned work items for space priority in descending order. Items not listed shall have the same precedence as similar items.
1. Reflected ceiling with all light fixtures, access above light fixtures required for maintenance, sprinkler head locations, and all ceiling fixtures and devices.
2. Space designed for future utility placement.
3. Gravity flow plumbing waste, roof drainage, and other systems that rely upon gravity for flow.
4. Ductwork and appurtenances, except that external bracing shall be relocated to accommodate local interference.
5. Fire sprinkler piping.
6. Cable tray with access identification 8 inches horizontal to 6 inches above tray.
7. Electrical conduit over 2 inches in diameter.
8. HVAC piping except for pressurized domestic water piping.
9. Plumbing vents.
10. Electrical conduit under 2 inches in diameter.

B. Plan all work so it proceeds with a minimum of interference with other trades.

C. It shall also be the responsibility of the Mechanical Contractor to inform the Contractor of all openings required in the building construction for the installation of the mechanical work.

D. The Contractor shall cooperate with all other contractors in furnishing material and information, in proper sequence, for the correct location of all sleeves, inserts, foundations, wiring, etc.

E. Provisions shall be made for all special frames, openings, and sleeves as required.

F. The Contractor shall pay for extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

3.5 ELECTRICAL WIRING

A. Install wiring in accordance with National Electric Code, ANSI/NFPA 70.

B. All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable. All wiring running exposed in air plenums shall be plenum cable.

C. Install wiring (low and line voltage) in metal raceways or conduit unless inside control cabinet or unit enclosures.
1. For concealed and accessible areas, plenum-rated wiring and cabling may be used.

D. Low voltage wiring not installed in conduit shall be supported every five feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.

E. Low voltage control wiring and 24 VAC can be run in the same conduit. Power wiring 120 VAC and greater must be in a separate conduit.

F. Fastening shall be secured to walls or ceilings by means of appropriate screws, expansion screws anchors, toggle bolts, hollow wall screw anchors, nylon expansion anchors, or expansion shields. All-purpose plastic anchors are not acceptable.

G. Locate circuits, relays, transformers, or other equipment that contains or must be connected to voltages exceeding 130 volts, in separate cabinets, which may be adjacent to control panels; permanently label "DANGER 277 VOLTS" or appropriate volts.

H. All wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size shall be 3/4 inch.

3.6 CONTROL WIRING AND POWER CONNECTIONS

A. Provide all incidental control power and wiring required to make the equipment or systems fully operational. Coordinate with equipment manufacture incidental wiring requirements.

B. Unless indicted elsewhere, provide line voltage, 120VAC, 20 amp dedicated control power circuits and LAN outlet to each of the following and as indicated:
   1. BMCS Control panel, 1 circuit.
   2. Coordinate required 120V power circuits and LAN outlets with Electrical Contractor.

C. Incidental control wiring includes but not limited to:
   1. HVAC Controls (Including but not limited to):
      a. Manufacturer's Packaged Control Systems
      b. Air Terminal Units
      c. Transmitters
   2. Packaged Rooftop Air Handling Units
   3. Packaged Split System Air Handling Units

3.7 LAYING OUT WORK

A. Carefully lay out all work in advance of installation using data and measurements from the site, the appropriate architectural and structural drawings, and shop drawings.

B. Equipment layout and all system layouts shall confirm adequate clearances for installation, operation, maintenance, and code-required clearances from the structure or other equipment and systems.

C. Provide offsets and elevation changes in conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.

D. The layout shall not cause problems of operation, maintenance, or clearance for items installed by other Contractors.

E. Prior to installation of any work, make certain the location does not conflict with other items in or near the same location.

F. If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Engineer prior to installation and shall request clarification.

G. Failure to properly coordinate and lay out the work will require correction by the Contractors at their own expense.

3.8 DATA AND MEASUREMENTS

A. Mechanical and electrical drawings are diagrammatic or schematic. Do not scale drawings.

B. The data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed.

C. Obtain exact locations, measurements, levels, etc., at the site and shall adapt their work to actual conditions.

D. Examine the general construction, mechanical, electrical, and other applicable drawings and the Specifications.

E. Layout and coordinate all work prior to installation to provide clearances for operation, maintenance and codes. Verify non-interference with other work.

3.9 POSITION OF DEVICES

A. Locate devices mounted on finished surfaces with regard to paneling, furring, trim, etc. Where several devices occur in a room, they shall be symmetrically arranged as reviewed by the Engineer.

B. Devices improperly located or installed shall be repaired, replaced or relocated at the Contractor's expense.

C. Devices shall be set plumb or horizontal and shall extend to the finished surface of the wall, ceiling, or floor without projecting beyond the surface.

D. Devices shown on wood trim, cases, or other fixtures shall be installed symmetrically and, where necessary, shall be set with the long dimension of the plate horizontal.

E. Coordinate their respective devices so as not to destroy the aesthetic effect of the surface in which the devices are mounted.

F. Coordinate the locations of all mechanical items with work furnished by other trades to avoid interference.

G. If the required coordination is not done, the outlets or devices shall be removed and relocated if so directed by the Engineer and the damaged surfaces repaired at the Contractor's expense.

H. Devices shall be installed at the height shown below unless otherwise noted. All heights of devices are measured from finished floor to centerline of device.

I. Heights may be adjusted to correspond to nearest masonry course or as necessary to clear wall-mounted cabinets, fin tube convectors, unit heaters, etc.
   1. Temperature control panels: 60 inches
   2. Thermostats: 48 inches
   3. Carbon dioxide (CO2) sensors: 48 inches

3.10 PROTECTION OF APPARATUS

A. Take such precautions as necessary to properly protect all apparatus, fixtures, appliances, material, equipment, and installations from damage of any kind.

B. Failure to provide such protection to the satisfaction of the Engineer shall be sufficient cause for the rejection of any particular piece(s) of material, apparatus, equipment, etc., concerned.

3.11 ACCESS TO EQUIPMENT

A. All motors, terminal boxes, valves, control devices, specialties, etc., shall be located to provide for easy access for operation, repair and maintenance; if concealed, access doors shall be provided.

B. Access doors required for access to equipment requiring inspection or service shall be provided.

C. Provide all access doors not already furnished by other Contractors but which are required for access to mechanical equipment.

D. Doors shall be 12 inches by 12 inches unless shown otherwise.

E. Person access doors shall be 18 inches by 18 inches minimum.

3.12 ROADWAYS, CURBS, AND WALKS

A. Use every possible precaution to prevent injuries to roadways, curbs, and walks on or adjacent to the site of the work.

B. Any damage shall be repaired at the Contractor's own expense. This shall also include damage necessary for installation of the mechanical work.

3.13 WORK IN EXISTING BUILDINGS

A. General: All work in the existing building, indicated on the drawings or specified herein, shall be executed with a minimum amount of interference with the normal activities of the occupants of the building.

B. All work shall be scheduled in advance with the Owner and shall not proceed without the Owner's written approval.

C. Utilities: Utilities shall not be interrupted without the Owner's prior written approval regarding the time and duration of such interruptions.
   1. Utilities to existing facilities shall not be disconnected until new or temporary facilities are installed except for short periods of interruption which are necessary for the performance of the new work and which are approved by the Owner.

D. Storm water may be temporarily diverted to surface drainage provided such drainage is arranged to prevent flooding of structures, basements, and excavations for construction.

E. Fire Alarm System: The existing fire alarm system shall remain functional throughout construction.
   1. As a minimum, the existing degree of protection shall be maintained for all areas.
   2. All required outages shall be coordinated with the Owner and the Fire Marshal.

F. Welding: The Owner shall be notified before starting welding or cutting.
   1. Fire extinguishers shall be immediately accessible when welding or cutting with an open flame or arc.
   2. Welding or cutting with an open flame or arc shall be stopped not less than one hour before leaving the premises.

G. Noisy Operations: Noisy operations such as those involving use of air hammers, etc., in demolition, or cutting of openings shall be scheduled with the Owner.

H. Occupancy:
   1. The Owner will continue to occupy the building and carry on normal activity. Each Contractor shall protect the occupied areas from dust, smoke, etc., by a method reviewed by the Engineer.

I. Owner's Right to Direct Work: The Owner shall have the right to direct the places of beginning work, its prosecution, and the manner in which all work under this contract is to be conducted, insofar as may be necessary to secure the safe and proper progress and quality of the work.

J. Coordinate locations of new fire suppression, plumbing and HVAC penetrations through existing structure and construction. Utilize all existing documentation of conditions for coordination. Verify penetrations utilizing GPR (Ground Penetrating Radar) as necessary to confirm penetration locations.

K. Cutting and Patching:
   1. Each Contractor shall be responsible for all cutting and patching required for the work.

2. Patching shall be done by persons skilled in the trade involved and shall be prepared to receive paint.
3. Openings through floors may be drilled up to 1 inch but shall be core drilled over 1 inch.
4. Whenever the building surfaces (walls, floors, etc.) and openings are modified, removed and/or replaced to accommodate the new work or to introduce into or remove items from the building, such surfaces or openings shall be carefully reinstalled in conformance with the applicable code to protect the integrity of the building.

L. Existing Piping, Ductwork, or Mechanical Equipment:
1. If any existing piping, ductwork or mechanical equipment is encountered which would interfere with the proper installation of new work, it shall be removed or relocated as required or as directed by the Engineer.
2. Where existing work is to be modified, it shall be done in conformance with these specifications.
3. Materials used shall be the same as for new work unless otherwise specified.

3.14 DEMOLITION

A. Information pertaining to the existing building has been obtained through the buildings original drawings where available. Report discrepancies to the architect/engineer prior to any demolition. Contractor shall field verify all existing conditions prior to commencing work.

B. The Owner shall have the first right of salvage for all items being removed or demolished. If owner declines, the contractor shall remove from the premises and dispose of properly. Verify owner's intent prior to removal or demolition.

C. Coordinate shut down of all utilities for demolition work with the owner.

D. Coordinate demolition with the work of other trades. Provide temporary utilities as required to allow the work of other trades to proceed.

E. Remove all items and systems as indicated.

F. Disconnect, demolish, and remove systems, equipment, and components indicated to be removed.
1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

G. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.15 FINISHED SURFACES PENETRATIONS

A. All piping and ductwork penetrations of finished surfaces shall have escutcheons and/or closure plates.

B. Openings shall be cut only as large as required for the installation, sleeves, and/or frames installed flush with finished surfaces and grouted in place.

C. Surfaces around openings shall be left smooth and finished to match surrounding surface.

D. Duct frames and pipe sleeves through floors in concealed locations and in unfinished spaces such as mechanical rooms, etc., shall extend 2 inches above finished floor level and shall be caulked watertight.

E. All other sleeves shall extend approximately 1/4 inch above finished floor but shall allow placement of escutcheons.

3.16 FIRESTOPPING PENETRATIONS IN FIRE-RATED WALL/FLOOR ASSEMBLIES

A. Subject to compliance with the requirements of Division 07.

B. Provide proper sizing when providing sleeves or core-drilled holes to accommodate their work through penetrating items.

C. All voids between sleeve or core-drilled hole and pipe passing through shall be firestopped to meet the requirements of ASTM E814.

D. Install all materials complete, attached securely and permanently in place in accordance with manufacturers' printed directions.

E. Install materials in manner described in fire test report and in accordance with manufacturer's instructions, completely closing openings.

F. Do not cover installed firestopping until inspected by authority having jurisdiction.

G. Install labeling required by code.

3.17 PIPING AND/OR DUCTWORK SYSTEMS - COMMON REQUIREMENTS

A. General: Install as described below, unless individual Sections specify otherwise. Individual Sections specify unique installation requirements.

B. General Locations and Arrangements:
1. Drawing plans, schematics, and diagrams indicate general, diagrammatic location and arrangement of systems.

2. Indicated locations and arrangements were used to sizeductwork and calculate friction loss and fan sizing, and other design considerations.
3. Install systems as indicated, unless deviations to layout are approved on Coordination Drawings.
4. Provide offsets and elevation changes in ductwork, piping and conduit as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
5. Do not run ductwork and piping above electrical panels or in code required clearance spaces.
6. Do not run ductwork, piping, and plumbing above or through information technology and data closets, IDF, and MDF rooms. Coordinate all routing with other trades.
7. Coordinate location of ductwork with electrical cable tray. Provide a minimum of 6" of clear access above cable tray for installation of cables.
8. Install exposed interior and exterior piping and ductwork at right angles or parallel to building walls.
    a. Diagonal runs are prohibited, unless otherwise indicated.
9. Conceal ductwork in walls, pipe chases, utility chases, above ceilings, below grade or floors, unless otherwise noted, except in mechanical rooms or service areas.
10. Install ductwork to allow application of insulation plus 1-inch clearance around insulation.
11. Provide components with pressure rating equal to or greater than system operating pressure.
12. Install fittings for changes in direction and branch connections.
13. Install piping free of sags or bends with ample space between piping to permit proper insulation applications.
14. Install ductwork and piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building unless otherwise indicated.
    a. Allow sufficient space above ceiling panels to allow for ceiling panel removal.
15. Install ductwork and piping to allow for expansion and contraction without stressing pipe, adjacent building structure or connecting equipment.
    a. Provide expansion loops or compensators where indicated.
16. Do not use ceiling support system to bear weight of devices or systems unless ceiling support system is certified as suitable to do so.
17. During construction, avoid any undue loads, forces or strains on valves, equipment, pumps flanges, or building elements with piping connections or piping systems.
18. Keep all duct and equipment openings closed during construction except when actual work is being performed on that item or system.
19. Roof mounted piping, conduit and ductwork:
    a. Coordinate all roof mounted support locations and loads with roofing contractor.
    b. Space supports per all applicable codes and as indicated.
    c. Provide 18" minimum under pipe, duct and conduit, to allow for roof repair.

C. Contractor is responsible for any cutting and patching needed for mechanical installation. Patching must match existing.

D. Verify final equipment locations for roughing-in of all systems.

3.18 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to manufacturer's requirements and submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Engineer.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components.

E. Connect equipment for ease of disconnecting, with minimum interference to other installations.

3.19 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1, "Structural Welding Code--Steel."

3.20 INCIDENTAL WORK

A. The following incidental work shall be furnished by the designated contractor under the supervision of the Temperature Control Contractor:
   1. The Air Distribution Contractor shall install all automatic dampers furnished by the Temperature Control Contractor.
   2. The Air Distribution Contractor shall provide necessary blank-off plates (safing) required to install dampers that are smaller than duct size.
   3. The Electrical Contractor shall provide power wiring to air terminal unit controller transformers.
   4. The Electrical Contractor shall provide conduit between the refrigerant leak detection systems at the rooftop air handling units and the electric duct heaters in the supply ductwork they serve.
   5. The Air Distribution Contractor shall provide access doors or other approved means of access through ducts for service to control equipment.
   6. Supply and return air motorized smoke dampers shall be provided by the Air Distribution Contractor on all air handling units 15,000 cfm and larger, as required by NFPA 90A, and shall be controlled by the Temperature Control Contractor. Dampers shall close when fan stops and open when fan starts.

3.21 EQUIPMENT AND SYSTEM SOFTWARE INTERFACES TO THE BMCS

A. Contractor shall coordinate with the BMCS Contractor to determine the points that are to be mapped from the equipment and systems to the BMCS. Contractor shall provide details of the method of integration and the information to be transferred between the systems as part of the submittal package.

B. Contractor shall provide the necessary software communication ports specifically for the interfacing of the systems to the BMCS.

C. Contractor cannot document that the exact same interface has been performed between the selected BMCS and the equipment and/or system, then the interfaces shall be tested prior to installations at an offsite location. The equipment shall not be installed at the project location until all software interfaces to the BMCS have been successfully demonstrated or documented.

D. Documentation regarding the software interfaces shall be provided in sufficient detail as to enable a person reasonably skilled in the writing of real time software applications to add/delete points mapped from one system to the other. The documentation shall include a detailed description of each protocol used and the model, version and firmware details of any protocol converter (gateway) that is used.

E. Refer to BMCS specifications for coordination and testing requirements.

3.22 LUBRICATION, TESTING AND TEST REPORTS

A. Upon completion of the work, the entire system shall be tested and proven for capacity of equipment, balance of system, proper operation of controls, and comfort of conditioned spaces.
   1. Prior to beginning systems testing, adjusting and balancing, replace all filter media with new media.
   2. Test and balance procedures and documentation shall be in accordance with AABC, NEBB, or SMACNA unless indicated otherwise.
   3. Take air readings and submit copy of same to demonstrate proper flow according to the performances shown on the plans and noted in the specifications.
   4. Lubricate moving parts and clean or replace filters.
      a. Run in all bearings and, after they are run in, drain and flush bearings and refill with a new oil charge.
      b. Equipment shall be so arranged that tools (screwdrivers, wrenches, etc.) will not be required to make lubrication points accessible.
      c. Extensions on grease or oil fittings shall be provided where required for access to lubricate.
   5. Test ductwork systems per SMACNA and applicable codes and standards.
   6. Submit all test reports to the Engineer for review prior to date of substantial completion.
   7. Equipment and systems discrepancies shall be corrected prior to final acceptance.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Stencils.

D. Pipe markers.

E. ASME A13.1 - Scheme for the Identification of Piping Systems.

F. ASTM D709 - Standard Specification for Laminated Thermosetting Materials.

1.2 SUBMITTALS

A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

C. Product Data: Provide manufacturers catalog literature for each product required.

D. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

A. Rooftop Units: Stencilled painting.

B. Split System Air Handlers, Concealed: Stencilled painting or nameplastes.

C. Air Terminal Units: Nameplates.

D. Control Panels: Nameplates.

E. Piping: Pipe markers.

F. Relays: Tags.

G. Thermostats and space sensors: Nameplates.

2.2 NAMEPLATES

A. Manufacturers:
1. Advanced Graphic Engraving, LLC: www.advancedgraphicengraving.com.
2. Brimar Industries, Inc.: www.pipemarker.com.
3. Craftmark Pipe Markers: www.craftmarkid.com/#sle.
4. Kolbi Pipe Marker Co.: www.kolbipipemarkers.com.
5. Seton Identification Products, a Tricor Direct Company: www.seton.com.

B. Description: Laminated three-layer plastic with engraved letters.
1. Letter Color: White.
2. Letter Height: 1/2 inch.
3. Background Color: Black.
4. Plastic: Comply with ASTM D709.

2.3 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch octagonal.

B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch octagonal with smooth edges.

C. Valve Tag Schedule: In Valve and Equipment Binder.

2.4 STENCILS

A. Stencils: With clean cut symbols and letters of following size:
1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
4. Ductwork and Equipment: 2-1/2 inch high letters.

B. Stencil Paint: Semi-gloss enamel, colors complying with ASME A13.1.

2.5 PIPE MARKERS

A. Color: Comply with ASME A13.1.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.

D. Color code as follows:

1. Heating, Cooling, and Boiler Feedwater: Green with white letters.
2. Toxic and Corrosive Fluids: Orange with black letters.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 TAGS

A. Install tags with corrosion-resistant chain.

B. Identify valves in main and branch piping with tags.

C. Identify air terminal units coil valves with numbered tags.

D. Tag automatic controls, instruments, and relays. Keep to control schematic.

E. Identify small devices such as in-line pumps with tags.

F. Identify pipe 1 inch and smaller with tags.

3.3 PIPE MARKERS

A. Install plastic pipe markers in accordance with manufacturer's instructions.

B. Install plastic tape pipe markers complete/around pipe in accordance with manufacturer's instructions.

C. Identify piping, concealed or exposed, with plastic pipe markers. Identify service, flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure and at each obstruction.

D. All underground piping systems shall have a non-metallic warning tape, with appropriate warning, buried 24 inches above top of pipe.

3.4 NAME PLATES

A. Install plastic name plates with the manufacturer's recommended adhesive.

B. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates.

C. Identify control panels and major control components outside panels with plastic nameplates.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems and components.

B. Measurement of final operating condition of HVAC systems.

1.2 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

J. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

K. TAB: Testing, adjusting, and balancing.

L. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

M. Test: A procedure to determine quantitative performance of systems or equipment.

N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 REFERENCE STANDARDS

A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition.

B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.

C. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems.

D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing.

E. TABB - Testing, Adjusting, and Balancing Bureau.

1.4 SUBMITTALS

A. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to Engineer.
   2. Submit six weeks prior to starting the testing, adjusting, and balancing work.
   3. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified below and in Part 3.
   4. Include certification that the plan developer has reviewed Contract Documents, the equipment and systems, and the control system with the Engineer and other installers to sufficiently understand the design intent for each system.
   5. Include at least the following in the plan:
      a. Preface: An explanation of the intended use of the control system.
      b. List of all air flow, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
      c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
      d. Identification and types of measurement instruments to be used and their most recent calibration date.
      e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
      f. Final test report forms to be used.
      g. Detailed step-by-step procedures for TAB work for each system and issue, including:
         1) Terminal flow calibration (for each terminal type).
         2) Diffuser proportioning.
         3) Branch/submain proportioning.
         4) Total flow calculations.
         5) Rechecking.

6) Diversity issues.

h. Expected problems and solutions, etc.

i. Criteria for using air flow straighteners or relocating flow stations and sensors; analogous explanations for the water side.

j. Details of how TOTAL flow will be determined; for example:

1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.

k. Specific procedures that will ensure that both air side systems are operating at the lowest possible pressures and methods to verify this.

l. Confirmation of understanding of the outside air ventilation criteria under all conditions.

m. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).

n. Method of checking building static and exhaust fan and/or relief damper capacity.

o. Proposed selection points for sound measurements and sound measurement methods.

p. Methods for making coil or other system plant capacity measurements, if specified.

q. Time schedule for TAB work to be done in phases (by floor, etc.).

r. Description of TAB work for areas to be built out later, if any.

s. Time schedule for deferred or seasonal TAB work, if specified.

t. False loading of systems to complete TAB work, if specified.

u. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.

v. Interstitial cavity differential pressure measurements and calculations, if specified.

w. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

x. Procedures for formal progress reports, including scope and frequency.

y. Procedures for formal deficiency reports, including scope, frequency and distribution.

B. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

1. Revise TAB plan to reflect actual procedures and submit as part of final report.

2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.

3. Provide reports in electronic, word searchable, .pdf format binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.

5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.

6. Units of Measure: Report data in I-P (inch-pound) units only.
7. Include the following on the title page of each report:
    a. Name of Testing, Adjusting, and Balancing Agency.
    b. Address of Testing, Adjusting, and Balancing Agency.
    c. Telephone number of Testing, Adjusting, and Balancing Agency.
    d. Project name.
    e. Project location.
    f. Project Engineer.
    g. Project Engineer.
    h. Project Contractor.
    i. Project altitude.
    j. Report date.
    k. Certification sheet signed and sealed by the certified testing and balancing engineer.

C. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

D. Project Record Documents: Record actual locations of flow measuring stations, balancing dampers, and balancing dampers.

E. As-Balanced Record Fan Curves: Record actual balanced points on the manufacture's submitted fan curves.
1. Record system curves and actual RPM data for all fans.
2. Record system curves, actual RPM and final impeller diameter for all pumps.

F. Final Report Contents: In addition to certified field report data, include the following:
1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

1.5 PROJECT CONDITIONS

A. The entire TAB process shall be completed prior to Owner Occupancy.

1.6 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. Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS

2.1 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
   1. AABC (NSTSB), AABC National Standards for Total System Balance.
   2. SMACNA (TAB).
   3. Maintain at least one copy of the standard to be used at project site at all times.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

D. TAB Agency Qualifications:
   1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
   2. Having minimum of three years documented experience.
   3. Certified by one of the following:
      a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
      b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
      c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.

E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   5. Duct systems are clean of debris.
   6. Fans are rotating correctly.
   7. Fire and volume dampers are in place and open.
   8. Air coil fins are cleaned and combed.
   9. Access doors are closed and duct end caps are in place.
   10. Air outlets are installed and connected.
   11. Duct system leakage is minimized.
   12. Balancing dampers and devices are installed.

B. Examine equipment performance data including fan curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory.

C. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

D. Examine system and equipment test reports.

E. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

F. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

G. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

H. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

I. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

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

K. Examine automatic temperature control and building automation system components to verify the following:
   1. Check the sequence of operation of control devices are according to the Contract Documents..
   2. Dampers and other controlled devices are operated by the intended controller.
   3. Dampers are in the position indicated by the controller.
   4. Integrity of ampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in variable-air-volume terminals.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Sensors are located to sense only the intended conditions.
   7. Controller set points are set at indicated values. Controllers are calibrated and commissioned. Record controller settings and note variances between set points and actual measurements.
   8. Changeover from heating to cooling mode occurs according to indicated values.
   9. Transmitter and controller locations and note conditions that would adversely affect control functions.
   10. Operation of limiting controllers (i.e., high- and low-temperature controllers).
   11. Free travel and proper operation of control devices such as damper and valve operators.
   12. Interaction of electrically operated switch transducers.
   13. Interaction of interlock and lockout systems.
   14. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
   15. Note operation of electric actuators using spring return for proper fail-safe operations.

L. 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.

M. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer to facilitate spot checks during testing.

3.4 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

3.5 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems-Testing, Adjusting, and Balancing", and this Section.

B. Cut insulation, ducts and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.6 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
   1. Running log of events and issues.
   2. Discrepancies, deficient or uncompleted work by others.
   3. Contract interpretation requests.
   4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.

C. Permanently mark settings dampers and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.7 AIR SYSTEM PROCEDURE

A. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

B. Check dampers for proper position to achieve desired airflow path.

C. Check for airflow blockages.

D. Check condensate drains for proper connections and functioning.

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

F. Check for proper sealing of air duct system.

G. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

H. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

I. Measure air quantities at air inlets and outlets.

J. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

K. Adjusting:
   1. After installation, adjust diffusers, registers, and grilles to air patterns indicated, as directed and as required to prevent drafts before starting air balancing.
   2. Adjust air patterns per manufactures recommendations based on installed conditions.

L. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

M. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

N. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

O. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

P. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

Q. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

R. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

S. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

T. On electric heating coils, adjust system to provide required minimum airflow or downstream pressure differential to activate controls.

U. Compensating for Diversity in Variable Volume Systems: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

3.8 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.9 SCOPE

A. Test, adjust, and balance the following:
1. Packaged Roof Top Heating/Cooling Units.
2. Variable Air Volume Terminal Units.
3. Air Inlets and Outlets.

3.10 MINIMUM DATA TO BE REPORTED

A. Packaged Roof Top Heating/Cooling Units:
1. Unit identification.
2. Location.
3. Make and type.
4. Model number and unit size.
5. Manufacturer's serial number.
6. Unit arrangement and class.
7. Discharge arrangement.
8. Motor Data:
a. 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. Sheave dimensions, center-to-center, and amount of adjustments in inches.
g. Variable frequency controller position.

9. Total airflow rate in cfm.
10. Return air flow, specified and actual
11. Outside air flow, specified and actual
12. Relief/exhaust air flow (power exhaust), specified and actual
13. Total system static pressure in inches wg.
14. Fan rpm.
15. Discharge static pressure in inches wg.
16. Filter static-pressure differential in inches wg.
17. Outside-air damper position.
18. Return-air damper position.

B. Supply and Power Exhaust Fans:
1. Unit identification.
2. Location.
3. Manufacturer.
4. Model number.
5. Serial number.
6. Arrangement/Class/Discharge.
7. Air flow, specified and actual.
8. Total static pressure (total external), specified and actual.
9. Inlet pressure.
10. Discharge pressure.
11. Fan RPM.

C. Return Air/Outside Air:
1. Identification/location.
2. Design air flow.
3. Actual air flow.
4. Design return air flow.
5. Actual return air flow.
6. Design outside air flow.
7. Actual outside air flow.
8. Return air temperature.
9. Outside air temperature.
10. Required mixed air temperature.
11. Actual mixed air temperature.
12. Design outside/return air ratio.
13. Actual outside/return air ratio.

D. Duct Traverses:
1. System zone/branch.
2. Duct size.

3. Area.
4. Design velocity.
5. Design air flow.
6. Test velocity.
7. Test air flow.
8. Duct static pressure.
9. Air temperature.
10. Air correction factor.

E. Air Terminal Unit Data:
1. Manufacturer.
2. Type, constant, variable, single, dual duct.
3. Identification/number.
4. Location.
5. Model number.
6. Size.
7. Minimum static pressure.
8. Minimum design air flow.
9. Maximum design air flow.
10. Maximum actual air flow.
11. Inlet static pressure.

F. Air Distribution Tests:
1. Air terminal number.
2. Room number/location.
3. Terminal type.
4. Terminal size.
5. Area factor.
6. Design velocity.
7. Design air flow.
8. Test (final) velocity.
9. Test (final) air flow.
10. Percent of design air flow.

G. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

END OF SECTION

SECTION 23 07 13

DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Duct insulation.

B. Duct liner.

C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

D. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

E. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.

F. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation.

G. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

I. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

J. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

K. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

L. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.2 SUBMITTALS

A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations. Show details for application of field-applied jackets.

B. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of experience and approved by manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density, thickness, and appropriate ASTM standard designation.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.5 FIELD CONDITIONS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, UL 723, ASTM E84, or UL 723.

B. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

D. Insulation products shall not contain asbestos, lead, mercury, mercury compounds, or formaldehyde.

E. Products shall be certified by UL GREENGUARD GOLD or Indoor Advantage Gold.

F. Products shall certified to meet or exceed UL Standard 2818 -2013 Gold Standard for Chemical Emissions for Building Materials, Finishes and Furnishings

G. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

H. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

2.2 GLASS FIBER, FLEXIBLE

A. Manufacturer:
1. CertainTeed Corporation: www.certainteed.com.
2. Johns Manville Corporation; : www.jm.com.
3. JP Lamborn Co: www.jpflex.com.
4. Knauf Insulation: www.knaufinsulation.com.
5. Manson Insulation, Inc.: www.mansoninsulation.com
6. Owens Corning Corp; : www.owenscorning.com.

B. Vapor Barrier Jacket:
1. FSK: Kraft paper with glass fiber scrim yard and bonded to aluminized film; 0.0032 inch vinyl.
2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure-sensitive tape.

C. Vapor Barrier Tape:
1. Aluminized foil film, with pressure sensitive acrylic based adhesive, 3 inches wide, 6.5 mils thick, 58-ounce force/inch adhesion, 23 lbf/inch tensile strength. Service temperature -40 - 250 degree F.

2.3 GLASS FIBER, RIGID

A. Manufacturer:
1. CertainTeed Corporation: www.certainteed.com.
2. Johns Manville Corporation; : www.jm.com.
3. Knauf Insulation: www.knaufinsulation.com.
4. Manson Insulation, Inc.: www.mansoninsulation.com
5. Owens Corning Corporation: www.ocbuildingspec.com.

B. Insulation: ASTM C 612; rigid, noncombustible board.
1. K Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
2. Maximum Service Temperature: 450 degrees F.
3. Maximum Water Vapor Absorption: 5.0 percent.
4. Maximum Density: 8.0 pcf.

C. Vapor Barrier Jacket:
1. FSK: Kraft paper with glass fiber scrim yard and bonded to aluminized film; 0.0032 inch vinyl.
2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure-sensitive tape.

D. Vapor Barrier Tape:
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive, 3 inches wide, 6.5 mils thick, 90-ounce force/inch adhesion, 40 lbf/inch tensile strength.

E. Indoor Vapor Barrier Finish:
1. Manufacturers:
a. Fosters Model Vapor Out 30-33.
b. Childers Model Chil Out, CP-33.
2. Cloth: Untreated; 9 oz/sq yd min. weight, glass fabric.
3. Vinyl emulsion type acrylic, compatible with insulation, white color.
4. Characteristics: 0.07 perm water-vapor permeance per ASTM E96, Procedure B at 45 mil dry film thickness; -20 degrees F to +180 degrees F temperature range; solid content, 55 percent by volume and 68 percent by weight per ASTM D 1644; white color.

2.4 DUCT LINER

A. Manufacturers:
1. Aeroflex USA, Inc: www.aeroflexusa.com.
2. Armacell LLC: www.armacell.us.
3. CertainTeed Corporation: www.certainteed.com.
4. Ductmate Industries, Inc, a DMI Company: www.ductmate.com.
5. Johns Manville: www.jm.com.
6. Owens Corning Corporation: www.ocbuildingspec.com.
7. RBX Corporation.

B. Elastomeric Foam Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
1. Minimum Service Temperature: Minus 40 degrees F.
2. Maximum Service Temperature: 180 degrees F.
3. Fungal Resistance: No growth when tested according to ASTM G21.
4. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F.
5. Minimum Noise Reduction Coefficients:
a. 1/2 inch Thickness: 0.30.
b. 1 inch Thickness: 0.40.
c. 1-1/2 inches Thickness: 0.50.
d. 2 inch Thickness: 0.60.
6. Erosion Resistance: Does not show evidence of breaking away, flaking off, or delamination at velocities of 10,000 fpm when tested in accordance with ASTM C1071.
7. Connection: Waterproof vapor barrier adhesive.
8. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. Comply with ASTM C916.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Insulated Ducts Conveying Air Below Ambient Temperature:
1. Provide insulation with vapor barrier jackets, with minimum installed R-value of 6.0.
2. Finish with tape and vapor barrier jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

D. Insulated Ducts Conveying Air Above Ambient Temperature:
1. Provide with or without standard vapor barrier jacket, with minimum installed R-value of 6.0.
2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

E. External Duct Insulation Application:
1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
2. Secure insulation without vapor barrier with staples, tape, or wires.
3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
6. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
    a. Apply adhesives according to manufacturer’s recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
    b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
    c. 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:
        1) 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.
        2) 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.
        3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
        4) Do not overcompress insulation during installation.
        5) Impale insulation over pins and attach speed washers.

6) 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.

d. 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 one edge and one 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.

1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor barrier seal.

2) Install vapor stops for ductwork and plenums operating below 50 degrees 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 two times the insulation thickness but not less than 3 inches.

e. 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.

f. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface.

g. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

7. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transition.

c. 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:

1) 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.

2) 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.

3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

4) Do not overcompress insulation during installation.

5) 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.

d. 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 one edge and one 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.

1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor barrier seals.

2) Install vapor stops for ductwork and plenums operating below 50 degrees 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 two times the insulation thickness but not less than 3 inches.

e. 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.

f. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Duct Liner Application:

1. Adhere insulation with adhesive for 100 percent coverage.
2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Seal liner surface penetrations with adhesive.
5. Duct dimensions indicated are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.
6. Lined ducts shall be fabricated to provide the net inside dimensions shown.
7. 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.
8. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
9. Butt transverse joints without gaps and coat joint with adhesive.
10. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
11. 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.
12. Apply adhesive coating on all longitudinal seams.

13. 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:
    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
14. 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.

3.3 DUCT INSULATION

A. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

B. 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.

C. Items Not Insulated:
1. Existing supply air ductwork that has existing duct wrap insulation or liner.
    a. Note: All new supply air ductwork shall be insulated. Uninsulated existing ductwork connecting to the new ductwork shall be insulated.
2. Existing ductwork concealed in chases.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Factory-insulated rooftop unit curbs.
6. Flexible connectors.
7. Vibration-control devices.
8. Factory-insulated access panels and doors.

3.4 INSULATION AND JACKET SCHEDULE

A. Duct Liner
1. Duct liner shall not be used on the following locations:
    a. Ahead of any coil on all air distribution systems.
2. Horizontal Above Ceiling Air Handlers (AH-1):
    a. Supply Air: 1-inch liner in all new ductwork downstream of unit.
3. Terminal Units:
    a. Supply Air: 1-inch liner in all new ductwork upstream and downstream.

B. Indoor Duct and Plenum
1. Supply Air:
    a. Concealed, supply-air duct insulation shall be any of the following:
        1) Glass-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
        2) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.

b. Exposed in Finished Space, rectangular, supply-air duct insulation shall be any of the following:
    1) Duct Liner: 1 inch thick in new ductwork only.
        (a) Note: Existing ductwork does not need to be relined except where existing liner is damaged during new construction.
c. Exposed in Finished Space, round or flat oval, supply-air duct insulation shall be any of the following:
    1) Duct Liner: 1 inch thick in new ductwork.
        (a) Note: Existing ductwork does not need to be relined except where existing liner is damaged during new construction.
d. Exposed in mechanical room, rectangular, supply-air duct insulation shall be any of the following:
    1) Glass-Fiber Blanket: 2 inchesthick and 1.5-lb/cu. ft.nominal density.
    2) Glass-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.
    3) Glass-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
    4) Note: New ductwork shall be insulated. Existing ductwork does not need to be reinsulated except where damaged during new con

2. Return Air:
    a. None.
3. Outdoor Air:
    a. Exposed in mechanical room, rectangular, outdoor-air duct insulation shall be any of the following:
        1) Glass-Fiber Blanket: 3 inchesthick and 1.5-lb/cu. ft.nominal density.
    b. Exposed in mechanical room, round and flat oval, outdoor-air duct insulation shall be any of the following:
        1) Glass-Fiber Blanket: 3 inches thick and 1.5-lb/cu. ft.nominal density.

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Piping insulation.

B. Jacketing and accessories.

C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

D. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.

F. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

G. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.

H. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.

I. ASTM C585 - Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.

J. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.

K. ASTM C610 - Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation.

L. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.

M. ASTM D1056 - Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.

N. ASTM D2842 - Standard Test Method for Water Absorption of Rigid Cellular Plastics.

O. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

P. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

Q. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.2 SUBMITTALS

A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

B. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

B. Applicator Qualifications: Company specializing in performing the type of work specified in this section and approved by manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.5 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, UL 723, ASTM E84, or UL 723.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Products shall be certified by UL GREENGUARD GOLD or Indoor Advantage Gold.

F. Products shall certified to meet or exceed UL Standard 2818 -2013 Gold Standard for Chemical Emissions for Building Materials, Finishes and Furnishings

G. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

H. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

2.2 GLASS FIBER, RIGID

A. Manufacturers:
1. CertainTeed Corporation: www.certainteed.com/#sle.
2. Johns Manville Corporation: www.jm.com/#sle.
3. Knauf Insulation: www.knaufinsulation.com/#sle.
4. Owens Corning Corporation: www.ocbuildingspec.com/sle.
5. Manson Insulation.

B. Insulation: ASTM C547and ASTM C795; rigid molded, noncombustible.
1. K Value: ASTM C177, 0.24 at 75 degrees F.
2. Maximum Service Temperature: 850 degrees F.
3. Maximum Moisture Absorption: 0.2 percent by volume.

C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.

2.3 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

A. Manufacturers:
1. Aeroflex USA, Inc: www.aeroflexusa.com/#sle.
2. Armacell International; Armaflex: www.armacell.com.
3. K-Flex USA LLC: www.kflexusa.com/#sle.
4. RBX Corp.

B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
1. K Value: {rs#1}; 0.25 at 75 degrees F.
2. Minimum Service Temperature: Minus 40 degrees F.
3. Maximum Service Temperature: 220 degrees F.
4. Moisture Vapor Permeability: .03 perm inch, when tested in accordance with {rs#1}.
5. Connection: Waterproof vapor barrier adhesive.

C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.4 JACKETS AND COVERS

A. PVC Plastic:
1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
a. Minimum Service Temperature: 0 degrees F.
b. Maximum Service Temperature: 150 degrees F.

c. Moisture Vapor Permeability: .02 perm inch, maximum, when tested in accordance with {rs#1}.
d. Thickness: 10 mil, 0.010 inch.
e. Connections: Brush on welding adhesive.

2. Covering Adhesive Mastic: Compatible with insulation.
a. Manufacturers:
1) Childers Products Vi Cryl CP-10/11.
2) Foster Products Weatherite 46-50.
3) Eagle Bridges - Marathon Industries, Inc.

B. Self-Adhering Jacketing:
1. Manufacturers:
a. Venture Tape
b. Fosters
c. Polyguard
2. Jacket: Multi-ply, laminated, flexible, self-adhering, protective jacketing, vapor barrier, and weatherproofing membrane.
a. Maximum Service Temperature: 250 degrees F.
b. Minimum Service Temperature: -40 degrees F.
c. Moisture Vapor Permeability: 0000 per inch, when tested in accordance with ASTM E-96.
d. Mold inhibitors incorporated.
e. UV stable.
f. Minimum Thickness: 5.0 mils.

2.5 ACCESSORIES

A. General Requirements:
1. Provide required accessories in accordance with and subject to the recommendations of the insulation manufacturer.
2. Furnish compatible materials which do not contribute to corrosion, soften, or otherwise attack surfaces to which applied, in either the wet or dry state.
3. Comply with ASTM C795 requirements for materials to be used on stainless steel surfaces.
4. Supply materials that are asbestos free.

PART 3 EXECUTION

3.1 EXAMINATION

A. Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.

B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Exposed Piping: Locate insulation and cover seams in least visible locations.

D. Insulated Pipes Conveying Fluids Below Ambient Temperature:
1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.

E. Glass Fiber Insulated Pipes Conveying Fluids Below Ambient Temperature:
1. Provide vapor barrier jackets, factory-applied or field-applied; secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Coat all elbows, fittings, valves and flanges with vapor barrier mastic and reinforcing mesh. Finish with PVC fitting covers.

F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

G. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

H. Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:
1. Provide standard jackets, with or without vapor barrier, factory-applied, or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with PVC fitting covers.

I. Inserts and Shields:
1. Application: Insulated piping 3/4 inches diameter or larger.
2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
3. Shield shall span an arc of 180 degrees.
4. Match diameter of shield to OD of insulation.
5. Shield dimensions shall not be less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
6. Insert location: Between support shield and piping and under the finish jacket.
7. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
8. Thermal-Hanger Shield Inserts: Install according to manufacturer’s written instructions.

J. Insulated Piping: Attach hangers and supports to piping as follows:
1. Piping Operating Above Ambient Temperature:
   a. Where piping is not supported on rollers or trapeze, hangers may project through insulation.
   b. For straight runs of piping, at points of support more than 100 feet from elbow or anchor point, use roller type supports.
   c. Where piping is supported on rollers or trapeze, support piping at outside diameter of insulation.

1) NPS Smaller than 2: Provide MSS SP-58, Type 40, protective shield.

2. Piping Operating Below Ambient Temperature: Support piping at outside diameter of insulation. Do not penetrate vapor barrier.
   a. NPS Smaller than 2: Provide MSS SP-58, Type 40, protective shield.

K. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, see Section 07 84 00.

3.3 GENERAL PIPE INSULATION INSTALLATION

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

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

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

3.4 INSULATION AND JACKET SCHEDULE

A. Insulation thickness listed below is based on the thermal conductivity performance of the material listed.
   1. Alternative material thickness must be adjusted as required to provide equivalent conductivity performance.
   2. Alternative material subtitution shall be reviewed by the Engineer.

B. Provide insulation thickness based on 2018 International Energy Conservation Code minimum requirements.

C. Indoor Piping:
   1. Refrigerant Piping and Tubing:
      a. Low Pressure Suction/Vapor (40-90 degrees F), all pipe sizes:
         1) Flexible Elastomeric: 1 inch thick.
      b. Liquid, all pipe sizes:
         1) Flexible Elastomeric: 1 1/2 inches thick.
   2. Condensate and Equipment Drain Water Below 60 Degrees F:
      a. All Pipe Sizes:
         1) Glass-Fiber, Preformed Pipe, Type I: 1/2 inch thick.

D. Outdoor, Above Ground Piping:
   1. Refrigerant Piping and Tubing:
      a. Low Pressure Suction/Vapor (40-90 degrees F), all pipe sizes:
         1) Flexible Elastomeric: 1 inch thick.
      b. Liquid, all pipe sizes:
         1) Flexible Elastomeric: 1 1/2 inches thick.
      c. Outdoor Jacketing: Self-Adhering or Removable UV and Vapor protection.

E. Outdoor, Field Applied Jacket and Covers:
   1. Install jacket/covers over all insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
   2. Piping, Exposed:
      a. Self-Adhering Jacketing: VentureClad, 1579GCW-WME, embossed white with adhesive and a membrane.
      b. Aluminum Jacket Fitting Covers (For Outdoor Use) :
         1) Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch (0.41 mm) with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
         2) Finish: White, Embossed.
         3) Fittings: 0.016 inch (0.40 mm) thick die-shaped fitting covers with factory-attached protective liner.

4) Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum.

END OF SECTION

SECTION 23 08 00

COMMISSIONING OF HVAC

PART 1 GENERAL

1.1 SUMMARY

A. See Section 01 91 13 - General Commissioning Requirements for overall objectives; comply with the requirements of Section 01 91 13.

B. HVAC system shall be Commissioned as required by all applicable building and energy codes.

C. This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.

D. The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.

E. The following HVAC equipment is to be commissioned, including commissioning activities for the following specific items:
   1. Control system.
   2. Ductwork and accessories.
   3. Terminal units.
   4. CO2-based demand controlled ventilation
   5. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.

F. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

G. International Energy Conservation Code, System Commissioning; 2015.

H. ASHRAE Guideline 1.1 - Application of the Commissioning Process to New HVAC&R Systems.

1.2 SUBMITTALS

A. Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
   1. System name.
   2. List of devices.
      a. Process of performing operational checks of each controlled component.
      b. Plan and process for calibrating valve and damper actuators and all sensors.

c. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

B. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.

C. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:

1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.
2. Full as-built set of control drawings.
3. Full as-built sequence of operations for each piece of equipment.
4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
   a. Floor.
   b. Room number.
   c. Room name.
   d. Air handler unit ID.
   e. Reference drawing number.
   f. Air terminal unit tag ID.
   g. Heating and/or cooling valve tag ID.
   h. Minimum air flow rate.
   i. Maximum air flow rate.
5. Full print out of all schedules and set points after testing and acceptance of the system.
6. Full as-built print out of software program.
7. Electronic copy on disk of the entire program for this facility.
8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
10. Control equipment component submittals, parts lists, etc.
11. Warranty requirements.
12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
    a. Sequences of operation.
    b. Control drawings.
    c. Points lists.
    d. Controller and/or module data.
    e. Thermostats and timers.
    f. Sensors and DP switches.
    g. Valves and valve actuators.

h. Dampers and damper actuators.
i. Program setups (software program printouts).

D. Project Record Documents: See Section 01 78 00 for additional requirements.
1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.

E. Draft Training Plan: In addition to requirements specified in Section 01 79 00, include:
1. Follow the recommendations of ASHRAE Guideline 1.1.
2. Control system manufacturer's recommended training.
3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.

F. Training Manuals: See Section 01 79 00 for additional requirements.
1. Provide three extra copies of the controls training manuals in a separate manual from the O&M manuals.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.

B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

PART 3 EXECUTION

3.1 PREPARATION

A. Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.

B. Furnish additional information requested by the Commissioning Authority.

C. Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for use by the Commissioning Authority; update the schedule as appropriate.

D. Notify the Commissioning Authority when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction notify ahead of time and be proactive in seeing that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.

E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.

F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.

G. Provide temperature and pressure taps in accordance with Contract Documents.
   1. Provide a pressure/temperature plug at each water sensor that is an input point to the control system.

3.2 INSPECTING AND TESTING - GENERAL

A. Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.

B. Perform the Functional Tests directed by the Commissioning Authority for each item of equipment or other assembly to be commissioned.

C. Provide two-way radios for use during the testing.

D. Valve/Damper Stroke Setup and Check:
   1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
   2. Set pump/fan to normal operating mode.
   3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
   4. Command valve/damper open; verify position is full open and adjust output signal as required.
   5. Command valve/damper to a few intermediate positions.
   6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

E. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.3 TAB COORDINATION

3.4 CONTROL SYSTEM FUNCTIONAL TESTING

A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of Contract Documents and the detailed Sequences of Operation documentation submittal.

B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with Contract Documents.

C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.

D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
   1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
   2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.

E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.

F. Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
   1. Setpoint changing features and functions.
   2. Sensor calibrations.

G. Demonstrate to the Commissioning Authority:
   1. That all specified functions and features are set up, debugged and fully operable.
   2. That scheduling features are fully functional and setup, including holidays.
   3. That all graphic screens and value readouts are completed.
   4. Correct date and time setting in central computer.
   5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
   6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to Owner.
   7. Power failure and battery backup and power-up restart functions.
   8. Global commands features.
   9. Security and access codes.
   10. Occupant over-rides (manual, telephone, key, keypad, etc.).
   11. O&M schedules and alarms.
   12. Occupancy sensors and controls.
   13. “After hours” use tracking and billing.
   14. Communications to remote sites.
   15. Fire alarm interlocks and response.
   16. Fire protection and suppression systems interfaces.
   17. Security system interlocks.
   18. That points that are monitored only, having no control function, are reporting properly to the control system.
   19. All control strategies and sequences not tested during controlled equipment testing.
   20. Trend logging and graphing features that are specified.
   21. Other integrated tests specified in Contract Documents
   22. That control system features that are included but not specified to be setup are actually installed.

H. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to Owner.

3.5 OPERATION AND MAINTENANCE MANUALS

A. See Section 01 78 00 for additional requirements.

B. Add design intent documentation furnished by Engineer to manuals prior to submission to Owner.

C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.

D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

END OF SECTION

SECTION 23 09 13.13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Control panels.

B. Power Supplies and Transformers.

C. Low Voltage Control Cable.

D. Input/Output Sensors:
1. Temperature sensors.
2. Humidity sensors.
3. Carbon dioxide sensors.

1.2 REFERENCE STANDARDS

A. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week before starting work of this section; require attendance by all affected installers.

1.4 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.
1. Manufacturer's printed data sheets for all control system components clearly identify data by component.
2. General catalog sheets, including details of construction, ratings, and dimensions for each component.

C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.
1. Show complete details of interconnections between temperature control systems and control specified with equipment or systems.
2. Provide dampers schedule indicating dimension and descriptions of blank-offs, installation location, arrangement, velocities, static pressure drop, damper features, identification, and part number.
3. Control panel locations indicated on plans.

4. Clearly note the proposed deviations from specified sequences and equipment, and substantiate with written explanation.

D. Manufacturer's Instructions: Provide for all manufactured components.

E. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

F. Project Record and Closeout Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.
1. Complete Index of Contents.
2. Revise shop drawings to reflect actual installation and operating sequences.
3. Red-mark "Record" control system drawings and then turn them over to the Owner's Representative.
4. Provide directions for calibration, adjustment, and maintenance instructions for each type of component.
5. Shop drawings of control system showing devices, interconnections between devices, and connections to items provided by others.
6. Specifications data sheets on each device.

G. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Extra Thermostats and Other Exposed Sensors: One of each type.

1.5 QUALITY ASSURANCE

A. Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed at the State in which the Project is located.

B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

C. Installer Qualifications: Company specializing in performing the work of this section with minimum five years experience approved by manufacturer.

D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. As indicated.

2.2 EQUIPMENT - GENERAL

A. Products Requiring Electrical and Control Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

2.3 CONTROL PANELS

A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gages, pilot lights, push buttons and switches flush on cabinet panel face.

B. {rs#1}, general purpose utility enclosures with enameled finished face panel.

C. Provide common keying for all panels.

D. Control panels shall meet the following minimum requirements:
   1. Outdoors: Control panels located outdoors shall comply with NEMA 3R or 4X requirements.
      a. Other Locations: Control panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.
   2. Provide panels of adequate size to accommodate instruments for future expansion of approximately 25% beyond space required for this scope of work.
   3. Cabling shall be terminated on rugged and easily accessible terminal strips. Each termination shall be clearly marked and shall be as detailed in the shop and record drawings.
   4. Panels mounted on vibrating equipment shall have vibration isolation protection that ensures their satisfactory operation.

E. Local Control Panels:
   1. In general, the control panels shall consist of the controller(s), display module, and I/O devices - such as relays, transducers, and so forth - that are not required to be located external to the control panel due to function. The display module shall be flush mounted in the panel face unless otherwise noted.
   2. All I/O connections on the controller shall be extended to a numbered, color-coded, and labeled terminal strip for ease of maintenance and expansion. Wiring to I/O devices shall be made from this terminal strip.
   3. All other wiring in the panel, internal and external, shall be made to additional line or low-voltage, color-coded, and labeled terminal strips. Low and line voltage wiring shall be segregated. All terminal strips and wiring shall be UL listed, 300-volt service, and provide adequate clearance for field wiring.
   4. All wiring for every control panel shall follow a common color-coded format. All terminal strip color coding and numbering shall follow a common format. All wiring shall be neatly installed in plastic trays or tie-wrapped.
   5. A convenience 120 VAC duplex receptacle, fused on/off power switch, and required transformers shall be provided in each enclosure.

2.4 POWER SUPPLIES AND TRANSFORMERS

A. DC Power Supplies:
1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75 percent of the rated capacity of the power supply.
2. Input: 120 VAC +10 percent, 60 Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05 percent for 10 percent line change.
5. Load Regulation: +0.05 percent for 50 percent load change.
6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
8. A power disconnect switch shall be provided next to the power supply.

B. Transformers and Air Terminal Unit Power:
1. Input frequency of 50/60 Hz.
2. Internal circuit breaker.
3. Foot Mounted
4. Temperature range of 32 Deg. F. to 104 Deg. F.
5. Sized to provide volts and amps as required for connected load.
6. Input voltage shall be as required for the specific application.
7. Transformers shall be panel mounted:
   a. Panels located in mechanical or electrical rooms shall comply with NEMA 4 requirements.
   b. Panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.
   c. Transformers and UPS can occupy the same panel enclosure.
   d. Transformer panels cannot contain other BMCS compoenets unless properly shielded.

C. DDC Power Supply Panel with Transformers:
1. Transformer: 500 VA
2. Over Current Protection: Circuit Breaker
3. Primary: 480/277/240/120 VAC
4. Frequency: 50/60 Hz
5. Nominal Dimensions: 12" x 12" x 6"
6. Approvals: Class 2 (UL Approved UL5085-3), UL916, UL508, C-UL, CE, RoHS
7. Housing: NEMA1 Metal Enclosure, Plenum Rated
8. Weight: 30.16 lbs.
9. 5 Secondaries: 24 VAC, with LED Indicators
10. 24 VAC ON/OFF: On / Off Switch & Breaker
11. Input: 480/277/240/120 VAC, Finger-Safe Terminals
12. Output: 5 Isolated, Floating 100 VA Class 2 24 Vac Terminals
13. Ambient Temperature Derating: 4A up to 40 degrees C; 3A up to 50 degrees C ; 2A up to 55 degrees C (When All 5 Outputs Operated Simultaneously)
14. Standby Wattage: 48.5 W @ 120 VAC
15. Full Load Primary Current: 4.6 A @ 120 VAC

16. Basis of Design: Functional Devices, Inc. Model no.: PSH500A, Enclosed Power Supply

D. Uninterruptable Emergency Power Supplies (UPS):

1. Output:
   a. Output Power Capacity: 1920 Watts / 1920 VA
   b. Max Configurable Power: 1980 Watts / 2200 VA
   c. Nominal Output Voltage: 120V
   d. Output Voltage Distortion: Less than 5%
   e. Output Frequency (sync to mains): 50/60Hz +/- 3 Hz
   f. Topology: Line Interactive
   g. Waveform Type: Sine wave
   h. Output Connections: (8) NEMA 5-15R, (2) NEMA 5-20R
2. Input:
   a. Nominal Input Voltage: 120V
   b. Input Frequency: 50/60 Hz +/- 3 Hz (auto sensing)
   c. Input Connections: NEMA 5-20P
   d. Cord Length: 6 feet (1.83 meters)
   e. Input voltage range for main operations: 82 - 144V
   f. Input voltage adjustable range for mains operation: 75 - 154V
3. Batteries & Runtime:
   a. Battery Type: Maintenance-free sealed Lead-Acid battery with suspended electrolyte : leakproof
   b. Typical recharge time: 3 hour(s)
4. Energy Use/Efficiency:

	Load	Efficiency
a.		
b.	25%	97.4%
c.	50%	98.2%
d.	75%	98.2%
e.	100%	98.1%

5. Communications & Management:
   a. Interface Port(s): (1) SmartSlot
   b. Control panel: Multi-function LCD status and control console
   c. Audible Alarm: Alarm when on battery : distinctive low battery alarm : configurable delays
   d. Emergency Power Off (EPO)
6. Surge Protection and Filtering:
   a. Surge energy rating: 530 Joules
   b. Filtering: Full time multi-pole noise filtering : 0.3% IEEE surge let-through : zero clamping response time : meets UL 1449
7. Environmental:
   a. Operating Environment: 32 - 104 °F
   b. Operating Relative Humidity: 0 - 95%
   c. Operating Elevation: 0-10000 feet
   d. Storage Temperature: 5 - 113 °F
   e. Storage Relative Humidity: 0 - 95%
   f. Storage Elevation: 0-50000 feet
   g. Audible noise at 1 meter from surface of unit: 45.00 dBA
   h. Online Thermal Dissipation: 275.00 BTU/h

8. Conformance:
    a. Regulatory Approvals: CSA, ENERGY STAR (USA), FCC Part 15 Class A, UL 1778
    b. Standard Warranty: 3 years repair or replace (excluding battery) and 2 year for battery, optional on-site warranties available, optional extended warranties available

2.5 LOW VOLTAGE CONTROL CABLE

A. All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable.

B. All wiring running exposed in air plenums shall be plenum cable.

C. Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC, and General Purpose Cabling:
1. Cable shall consist of copper conductors not less than #18 AWG stranded.
2. Cable shall be two- or three-conductor twisted cable with a drain wire.
3. Cable shall have a 100 percent overall shield.
4. Cable shall be plenum rated.
5. Cable shall meet or exceed NEC voltage rating of 300 volts.
6. Cable shall be NEC type CMP.
7. Cable shall meet or exceed UL temperature rating of +60 deg C.
8. Cable shall be labeled at a minimum of every 18 inches with the DDC system manufacturer's name and the type of signal carried within the cable, i.e., analog input, analog output, binary input, binary output, 24 VAC.

D. Primary and Secondary Communications Network Cabling:
1. Cable shall be of type recommended by the DDC system manufacturer.
2. Cable shall be shielded.
3. Cable shall be plenum rated.
4. Cable shall meet or exceed NEC voltage rating of 150 volts.
5. Cable shall meet or exceed UL temperature rating of +60 deg C.

2.6 INPUT/OUTPUT SENSORS

A. **Note:** Where packaged equipment (RTU, AHU, etc.) includes manufacturer furnished remote sensors to provide direct hardwired input to onboard controllers, install these according to the packaged equipment manufacturer's recommendations.
1. Do not duplicate the sensors with ones directly connected to the building managagement control system (BMCS), as the readings from the manufacturer furnished sensors will be accessible to the BMCS through the BACnet interfaces to the packaged equipment.
2. Do not send inputs from remote BMCS sensors to the packaged equipment onboard controllers via BACnet unless specifically indicated.
    a. EXCEPTION: RTU-1 and RTU-2 will receive remote CO2 level readings from the BMCS via BACnet to use in their demand controlled ventilation sequences. The BMCS will calculate the CO2 level inputs based on

multiple space CO2 sensors. See Specification Section 23 09 93 (Sequence of Operations for HVAC Controls) for more information.

B. Temperature Sensors:
1. Use thermistor or RTD type temperature sensing elements with characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy.
2. Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F.
3. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
4. Temperature Sensing Device: Compatible with project DDC controllers.
5. Performance Characteristics:
a. RTD:
1) Room Sensor Accuracy: Plus/minus 0.50 degrees F minimum.
2) Duct Averaging Accuracy: Plus/minus 0.50 degrees F minimum.
3) Chilled Water Accuracy: Plus/minus 0.50 degrees F minimum.
4) All Other Accuracy: Plus/minus 0.75 degrees F minimum.
5) Range: Minus 40 degrees F through 220 degrees F minimum.
b. Thermistor:
1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
2) Range: Minus 25 degrees F through 122 degrees F minimum.
3) Heat Dissipation Constant: 2.7 mW per degree C.
c. Temperature Transmitter:
1) Accuracy: 0.10 degree F minimum or plus/minus 0.20 percent of span.
2) Output: 4 to 20 mA.
d. Sensing Range:
1) Provide limited range sensors if required to sense the range expected for a respective point.
2) Use RTD type sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
3) Use temperature transmitters in conjunction with RTD's when RTD's are incompatible with DDC controller direct temperature input.
e. Wire Resistance:
1) Use appropriate wire size to limit temperature offset due to wire resistance to 1.0 degree F or use temperature transmitter when offset is greater than 1.0 degree F due to wire resistance.
2) Compensate for wire resistance in software input definition when feature is available in the DDC controller.
f. Room Temperature Sensors:
1) Construct for surface or wall box mounting.
2) Provide the following:
(a) Momentary override request push button for activation of after-hours operation.
(b) Blank faceplate without digital display or setpoint adjustment.
g. Duct Probe Temperature Sensors:

1) Application: Air handling applications where the coil or duct area is less than 10 square feet, and the air is not affected by stratification.
2) Sensor probe length shall be selected to provide the most representative reading from the sensed airstream.
3) Duct Mounted Sensor Requirements:
(a) Sensor Type: Thermistor.
(b) Accuracy: +/-0.4 °F over a 32 to 158 °F range.
(c) Measurement Resolution: 0.1 °F.
(d) Enclosure Material: Stainless Steel.

h. Outside Air Temperature Sensor:
1) The sensing element shall be fully encapsulated in potting material within a stainless-steel probe.
2) Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure.
3) Sensor Requirements:
(a) Operating range: -40 to 122 °F.
(b) Accuracy: +/-0.2 °F.
(c) Enclosure Material: ABS Plastic.

C. Humidity Sensors:
1. Duct Mounted and Wall Mounted Sensor: Voltage type encased in a plastic housing.
a. Input Power, Voltage Type: Class 2; 12-30 VDC/24 VAC, 15mA max.
b. Input Power, mA Type: Class 2; Loop powered 12-30 VDC only, 30 mA max.
c. Output Voltage Type: 3-wire observed polarity.
d. Output mA Type: 2-wire, not polarity sensitive (clipped and capped).
e. Humidity:
1) HS Element: Digitally profiled thin-film capacitive.
2) Accuracy 1 percent at 10 to 80 percent relative humidity at 77 degrees F, multi-point calibration, NIST traceable.
(a) Plus/minus 1 percent at 20 to 40 percent RH in mA output mode; (multi-point calibration, NIST traceable).
3) Scaling: 0 to 100 percent RH.
f. Temperature Effect:
1) Duct/Wall Mounted: Plus/minus 0.18 percent per degree F.
2) Outdoor Mounted: 4 to 20mA version: (0.0013x%RHx(TdegreeC-25)).
g. Hysteresis: 1.5 percent typical.
h. Linearity: Included in accuracy specification.
i. Reset Rate: 24 hours.
j. Stability: Plus/minus 1 percent at 68 degrees F (20 degrees C) annually, for two years.
k. Temperature Monitoring:
1) Temperature Transmitter Output: Digital, 4 to 20mA (clipped and capped) or 0-5V/0-10V output.
(a) HO Transmitter Accuracy: Plus/minus 2.3 degrees F.
(b) HD Transmitter Accuracy: Plus/minus 1.0 degree F.

l. Operating Environment:
1) Operating Humidity Range: 0 to 100 percent RH noncondensing.
2) Operating Temperature Range: Minus 40 degrees F to 122 degrees F.

2. Note: The room humidity sensors may be integrated with the room temperature and/or CO2 sensors.

D. Carbon Dioxide Sensors, Wall:
1. General: Provide non-dispersive infrared (NDIR), diffusion sampling CO2 sensors with integral transducers and linear output.
2. Air Temperature: Range of 32 to 122 degrees F.
3. Relative Humidity: Range of 0 to 95 percent (non-condensing).
4. Power Input: Class 2; 12 to 30VDC or 24VAC 50/60 Hz; 100mA max.
5. Calibration Characteristics:
a. Automatically compensating algorithm for sensor drift due to sensor degradation.
b. Maximum Drift: 2 percent.
c. User calibratable with a minimum calibration interval of 5 years.
6. Construction:
a. Sensor Chamber: Non-corrosive material for neutral effect on carbon dioxide sample.
b. Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.
c. Housing: High impact plastic.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

F. Ensure installation of components is complementary to installation of similar components.

G. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Check and verify location of exposed control sensors with plans and room details before installation. Locate 48 inches above floor unless otherwise noted. Align with lighting switches. Refer to Section 26 27 26.

C. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.

D. Provide insulated mounting bases on thermostats and other temperature sensing devices in the following locations:
   1. Exterior walls.
   2. Masonry/CMU walls.
   3. Interior walls that back up to mechanical/utility rooms and other non-conditioned spaces.

E. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

F. Provide boxes, conduit and electrical wiring in accordance with Section 26 05 83. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.
   1. Provide boxes and conduit pathways (to ceiling spaces), for all wall mounted thermostats and sensors and wiring. Refer to Division 26.

3.3 CONTROL PANELS

A. Control panel for each system where more than one control device requires field mounting, (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be mounted on piping, wall or ductwork. Install local control panel where indicated on Drawings or suitable location adjacent to system served.

B. Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.

C. Panels mounted on vibrating equipment shall have vibration isolation protection that ensures their satisfactory operation.

D. All control panels located in accessible areas be provided with keyed locks. Locks shall utilize a single master key. Provide 2 spare key sets to Owner.

E. Panel Layout:
   1. Locate controllers in lower half of panel first and upper half second.
   2. Locate terminal strips either horizontally in upper half of back panel or vertically. Do not locate terminal strips below 2'-0" or above 6' above finished floor.
   3. Separate 24 VDC and 120 VAC, wire, cable, and devices by 6" minimum space.

4. Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.
5. Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.

3.4 SENSORS AND INPUT/OUTPUT DEVICES

A. All input and output devices shall be installed per the manufacturer's recommendation.

B. Building Differential Air Pressure Applications: Transmitter's exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
1. Unless indicated otherwise, locate the exterior sensing tip near the building's main entrance.
2. The interior sensing tip shall be inconspicuous and located within a central corridor on the same level as the entrance.

C. Outside Air Humidity Sensors: Outside air relative humidity sensors shall be installed with a rain-proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with seal-tight fittings and stainless steel bushings.

D. Outside Air Sensors: Outside air sensors shall be mounted on the north wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air temperatures accurately. Sensors exposed to solar radiation must be installed with solar shields. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.

E. Duct Mount Sensors:
1. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
2. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
3. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

3.5 ELECTRICAL WIRING

A. Install wiring in accordance with National Electric Code, ANSI/NFPA 70.

B. All wiring materials covered by this section shall be in accordance with the latest revision of the National Electrical Code and applicable local codes and shall carry the UL label where applicable. All wiring running exposed in air plenums shall be plenum cable.

C. Install wiring (low and line voltage) in metal raceways or conduit unless inside control cabinet or unit enclosures. For concealed and accessible areas, plenum-rated wiring and cabling may be used.

D. Class 2 wiring not installed in conduit shall be supported every five feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.

E. Low voltage control wiring and 24 VAC can be run in the same conduit. Power wiring 120 VAC and greater must be in a separate conduit.

F. Fastening shall be secured to walls or ceilings by means of appropriate screws, expansion screws anchors, toggle bolts, hollow wall screw anchors, nylon expansion anchors, or expansion shields. All-purpose plastic anchors are not acceptable.

G. Locate circuits, relays, transformers, or other equipment that contains or must be connected to voltages exceeding 130 volts, in separate cabinets, which may be adjacent to control panels; permanently label "DANGER 277 VOLTS" or appropriate volts.

H. All wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size shall be 3/4 inch.

3.6 START-UP SERVICES

A. Verify proper location of each device and point-to-point system integrity. Correct as needed.

B. When installation is complete and automatic control system is placed in operation, adjust and calibrate all instruments and devices in system and ensure that system is operating in accord with specified sequences.

C. Diagnose component and system problems. Communicate irregularities to the appropriate contractor for correction.

D. Attend construction meetings as required to coordinate with other contractors and provide input during problem resolution.

3.7 IDENTIFICATION STANDARDS

A. If the owner utilizes a specific equipment or system indentification or naming convention, the contractor shall use for all systems, nameplates and equipment references in all project documentation.

B. Field Devices: All field devices shall be identified by a typed (not handwritten) securely attached tag label.

C. Controller Identification: All controllers shall be identified by typed (not handwritten) securely attached tag label.

D. Panel Identification: All local control panels shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.

E. Panel Devices: All panel devices shall be identified by a typed label securely fastened to the back plate of the local control panel.

F. Raceway Identification: All the covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating "Control System Wiring" affixed to the covers. Labels shall be typed, not handwritten.

G. Wire Identification: All low and line voltage control wiring shall be identified by a number or name, as referenced to the associated control diagram, at each end of the conductor cable. Identification number or name shall be permanently secured to the conductor or cable and shall be typed.

END OF SECTION

SECTION 23 09 23

DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Control System Interfaces

B. System description.

C. Operator interface.

D. Controllers.

E. Power supplies and line filtering.

F. System software.

G. Controller software.

H. HVAC control programs.

1.2 REFERENCE STANDARDS

A. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks.

B. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests.

C. NFPA 70 - National Electrical Code.

D. UL (DIR) - Online Certifications Directory.

1.3 DEFINITIONS

A. BMCS (Building Management & Control System): The complete building management and direct-digital control (DDC) system described in this specification section.

B. Provide: Furnish, install, commission, test, and warrant.

C. Furnish: Purchase and deliver to the appropriate installing Contractor, complete with every appurtenance, document, commission, and warranty.

1.4 CONTROL SYSTEM INTERFACES

A. **NOTE:** The existing museum rooftop units and electric zone duct heaters being replaced in this project are currently on a Honeywell WEBs-AX BMCS that is no longer supported by the manufacturer. This obsolete BMCS will be removed in this project. The new equipment in this project, including the new variable air volume rooftop units and

associated retrofit variable air terminal units shall be integrated into the existing long term supported Honeywell N4 BMCS that serves the existing IMAX theater HVAC systems and the existing museum variable air volume system served by the existing Daikin rooftop unit.

1. The existing Honeywell N4 BMCS shall be extended to the museum areas from the JACE controller in the theater basement mechanical room via one or more additional JACE controllers or BACnet/IP routers. The new equipment shall be terminated at this JACE or router via BACnet MS/TP, and provision shall be provided for up to 10 additional future VAV air terminal unit zones. It shall not be acceptable to route all of the new equipment directly back to the existing JACE controller in the theater basement mechanical room.

B. System shall fully support a multi-vendor environment and be able to interface and integrate third party systems via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.

C. The BMCS contractor shall coordinate with all contractors and the associated manufacturers responsible for the systems and shall determine the points that are to be mapped from the BMCS to the third party system and the points that are to be mapped from the third party system to the BMCS.

D. Control Interface Coordination Meeting(s):

1. The BMCS contractor shall meet with the contractors, equipment suppliers, manufacturers, etc. furnishing the equipment to coordinate information details and functions between the equipment and BMCS. Each contractor/supplier shall provide complete details of the proposed interface including the PICS (Protocol Implementation Conformance Statement) for BACnet equipment, hardware and software identifiers, wiring requirements, communication speeds and required network accessories.
2. The purpose of this meeting is to insure that there are no unresolved issues regarding the integration of equipment into the BMCS network and final coordination of all Sequences of Operation.
3. The meeting(s) shall include the Owner's Representative and Commissioning Authority.
4. Submittals for this equipment will not be reviewed prior to the completion of these meetings.

E. System and Equipment to BMCS Interfaces shall be provided for, but not limited to:

1. Manufacturer's packaged system control panels.
2. Packaged Variable Air Volume Roof-Top Units.
3. Variable Air Volume Terminal Units.
4. Packaged Single Zone Variable Air Volume Split Systems

F. Where it is possible to map points from one system to the other that are not identified in these Contract Documents, the BMCS contractor shall advise the Owner, Consultant, and Engineer; and they shall determine whether additional points are to be mapped from one system to the other.

G. Provide mapping, alarm configuration, and graphic creation of, at minimum, twice the listed point quantities within these documents and as directed by the Owner.

H. The BMCS contractor shall provide details of the method of integration and the information to be transferred between the systems as part of the shop drawing package.

I. Equipment manufacturer/contractor shall provide communication port specifically for the interfacing of the system to the BMCS.

J. The BMCS contractor shall be responsible for all cable, conduit, and suitable cable connectors to the port on the system and the BMCS and other components as necessary for the software communications link from the system to the BMCS.

K. The fact that the points are mapped from systems to the BMCS shall be transparent to the operator. It shall not be necessary for the BMCS operator to know that the points are mapped from another system in order to implement such functions as adding and deleting a mapped point on a report/graphic, adjusting schedules and alarm limits associated with a mapped point, including a mapped point in a sequence of operations, etc.

L. If the BMCS contractor cannot document that the exact same interface has been performed between the BMCS and the systems, then the interfaces shall be tested prior to installations at an offsite location. If the test is successful, the BMCS contractor shall advise the Owner and Engineer and a time shall be established that is acceptable to the Owner and Engineer when the interface can be demonstrated.

M. The BMCS hardware shall not be installed at the project location until all system interfaces to the BMCS have been successfully demonstrated or documented.

N. Contractor shall be responsible for providing all equipment necessary to perform the demonstration and for ensuring the presence at the testing of suitably skilled personnel from system manufacturer/contractor. The testing of the interface between the two systems shall verify, at minimum, that:
   1. All data points mapped from the system to the BMCS are displayed correctly on the BMCS monitor and have the same functionality as points directly monitored/controlled by the BMCS.
   2. All data points mapped from the BMCS to the system are displayed correctly on the systems monitor.
   3. All mapped points are identical with regard to value, engineering units, and significant digits on both systems.
   4. All points mapped from the system to the BMCS meet all of the specifications detailed in the contract documents for points directly monitored/controlled by the BMCS.
   5. The communications watchdog is functioning correctly.
   6. Communications speed between the two systems is satisfactory.
   7. Both systems restart and communications between the two systems resume following a power failure without operator intervention.

O. Site tests similar to those detailed above shall be repeated as part of the final acceptance testing.

P. Documentation regarding the BMCS software interfaces shall be provided in sufficient detail as to enable a person reasonably skilled in the writing of real time software applications to add/delete points mapped from one system to the other. At minimum, the documentation shall include a detailed description of each protocol used and the model, version, and firmware details of any protocol converter (gateway) that is used.

Q. A watchdog procedure must be implemented that enables the identification of the point of failure, i.e., where in the communications chain between the two systems did the failure occur. The watchdog function must operate at a frequency that detects a failure within 60 seconds.

1.5 SUBMITTALS

A. Specification Compliance Review.

B. Shop drawings and product data shall be in original searchable PDF format.

C. Product data shall be presented according to an included table of contents.

D. Product Data: Provide data for each system component and software module.

E. Shop Drawings:
1. Indicate trunk cable schematic showing programmable control unit locations, and trunk data conductors.
2. List connected data points, including connected control unit and input device.
3. All components and controllers inclusive or 3rd party shall have a points list for each. Deviation from contract documents shall be reported to design team with alternates and/or a reason for deviation.
4. Control drawings shall have a completed system architecture. Controllers and components inclusive to the control system as well as 3rd party controllers and components to be integrated and/or communicated with.
5. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration digital media containing graphics.
6. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
7. Indicate description and sequence of operation of operating, user, and application software.

F. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.

G. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.
1. Revise shop drawings to reflect actual installation and operating sequences.
2. Include submittals data in final "Record Documents" form.

3. All wiring pathways, connections, junctions, transformers, etc. shall be as-built of a floor plan drawings and included with record drawings.

H. Operation and Maintenance Data:
1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

I. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner s name and registered with manufacturer.

1.6 QUALITY ASSURANCE

A. Perform work in accordance with NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years of documented experience.

C. Installer Qualifications: Company specializing in performing work of the type specified and with minimum three years of documented experience.

D. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for purpose specified and indicated.

E. Comply with ASHRAE 135 for DDC system control components. BTL listed.

F. Security Standards and Reference Guides:
1. Transport Layer Security (TLS) TLS 1.3 (August 2018)
2. Enviromental Security Technology Certification Program (ESTCP) Cybersecurity Guidelines
3. Niagara Hardening Guide
   a. Using a VPN with Niagara Systems
4. Security in Internet-Connected Building Automation and Energy Management System
   a. http://www.incenergy.com/sites/default/files/Security%20WhitepaperBranded.pdf

1.7 WARRANTY

A. Correct defective Work within a 2 year period after Substantial Completion.

B. Provide five year manufacturer's warranty for field programmable micro-processor based units.

1.8 CONTRACTOR QUALIFICATIONS

A. The BMCS contractor shall:

1. Have a local staff in the area of trained personnel capable of giving instructions and providing routine and emergency maintenance on the BMCS, all components and software/firmware, and all other elements of the BMCS.
2. Have a proven record of experience in the supply and installation of equivalent systems over a minimum period of five years. Document at least three and no more than six projects of equal or greater size and complexity.
3. Have been a factory-certified representative for the BMCS manufacturer for a minimum of three years for design, installation, and maintenance of the proposed systems.
4. Have comprehensive local service and support facilities for the total BMCS as provided.
5. Maintain local, or have approved local contracted access to, supplies of essential expendable parts.

1.9 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
   1. Limiting use of software to equipment provided under these specifications.
   2. Limiting copying.
   3. Preserving confidentiality.
   4. Prohibiting transfer to a third party.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Honeywell: www.honeywell.com.
   1. N4.

2.2 SYSTEM DESCRIPTION

A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units.

B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.

C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

D. Controls for variable air volume terminals, reheat coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 23 09 13.

E. Provide control systems consisting of thermostats, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.

F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

G. BMCS Contractor shall be responsible for all electrical work associated with the BMCS.
   1. Perform all wiring in accordance with all local and national codes.
   2. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the division 26 specifications, NEC and local building code.
   3. Provide extension of 120 volt, 20 amp circuits and circuit breakers from Emergency power panels for all BMCS equipment, transformers and panel power. Provide and install local UPS Power supply for all BMCS system panels and equipment.
   4. Surge transient protection shall be incorporated in design of system to protect electrical components in all BMCS Controllers and operator's workstations.
   5. All low voltage electrical control wiring throughout the building whether in exposed areas shall be run in conduit in accordance with the division 26 specifications, local building code and the NEC.
   6. Provide all miscellaneous field device mounting and interconnecting wiring for all mechanical systems including rooftop units, air terminal units, and electric reheat coils.

2.3 OPERATOR FUNCTIONS - WEB-BASED BMCS

A. Operators shall have access to specific functions of the BMCS via a standard web browser interface, subject to password access assigned by the Owner. The web-based displays shall be XML based. The web-based access shall present information to the operators and tenants to accomplish the following:
   1. Tenants with low-level passwords shall be able to:
      a. Enter a start time, duration, and designate lighting only or HVAC/Lighting to start for after-hour service. Provide a report to show current charges for these after-hour services for each tenant on a zone-by-zone basis.
      b. Zone Setpoint Changes: These shall be constrained within an operator-determined value which shall be set initially at + and - 2 degrees F.
   2. Operators with the appropriate level and password shall be able to perform all specified functions specified in these documents.

B. All operator entries shall be coordinated with the BMCS to ensure seamless operations and tracking of all changes to history and archive databases.

C. System must support Android and Iphone access with support for mobile and tablet applications.

D. Operator must have access to all editing software from any browser. Available software must be imbedded on controller to support editing and sub-controller access if applicable.

E. Operator access shall not require the use of JAVA to access the Web Based user interface.

F. Provide all necessary web page creations, user name and passwords, and configurations to fully implement this feature for 200 users.

G. BMCS Security

1. General Security
    a. All internet facing user interface allowing remote access shall be placed behind a firewall or VPN.
    b. Consult with local IT staff for preferred method and verification of IT security policies.
    c. Contractor shall be responsible for a securable interface.
    d. User interface , if not directly protected by owner IT infrastructure security policies shall update security definitions on a regular basis. No less than once per week.
    e. Access from remote source shall be secured by HTTPS Hyper Text Transfer Protocol over SSL (Secure Socket Layer).
        1) An SSL Certificate shall be provided at no additional cost to the owner.
    f. Default credentials that are used to set up software shall not be available after installation.
    g. Disable FTP, Telnet, and any other services that may deem the system “unsecure”.
    h. Disable services that will not be used.
    i. Software updates shall be performed regularly.
    j. Contractor / vendor shall hold liability for all “third-party” software including graphics builders, software for sub-controllers, tech-support access, contractor admin / billing.
    k. All external memory required or used on-site shall be verified by local IT staff to be safe before being used on owner network.
    l. All laptops and workstations being added to the owners network must be approved and cleared before being added to the network.
    m. IP addresses shall be approved and provided by local IT staff.
2. Installation Security
    a. Install supervisory controller(s) in locked area with restricted access.
3. User Security
    a. Passwords:
        1) “Strong Password” functionality shall be available.
        2) Passwords shall expire after 90 days.
        3) A 15 day warning period of expiration shall be used.
        4) User password reset shall be available.
        5) Password history of 5 shall be enabled.
    b. Account lockout feature shall be used with a 30 second lockout period.
    c. 10 Maximum logins before lockout with a 5 minute lockout window.
    d. All lockout features shall be approved by local IT staff.
    e. Use a different account for each user.
    f. Use unique service type accounts(admin, user, view only, etc).
    g. Install read-only remote accessible account for design team and commissioning authority.
4. Applicable Security Standards and Reference Guides:
    a. Transport Layer Security (TLS) TLS 1.3 (August 2018)
    b. Enviromental Security Technology Certification Program (ESTCP) Cybersecurity Guidelines
    c. Niagara Hardening Guide

d. Using a VPN with Niagara Systems
e. Security in Internet-Connected Building Automation and Energy Management System
1) http://www.incenergy.com/sites/default/files/Security%20WhitepaperBranded.pdf

2.4 CONTROLLERS AND PANELS

A. Primary DDC panels as follows:
1. Minimum one (1) new BMCS system Primary DDC panel or BACnet/IP router per two floors of the museum (which is different than the IMAX theater area) to extend the existing Honeywell N4 system from the existing building JACE controller in the theater basement mechanical room. The new application specific controllers installed for the terminal units on a floor will be connected to the nearest BMCS panel or router.
2. It shall be acceptable to combine the following mechanical equipment into one (1) BMCS system Primary DDC panel or BACnet/IP router:
a. Variable Air Volume Terminal Units
b. Package Rooftop Air Handling Units
c. Packaged Split System Air Handling Units
d. Note: The new BMCS primary DDC panel or BACnet/IP router must allow for up to 10 future application specific controllers for terminal units.

B. Building Controllers
1. General:
a. Additional building controllers shall only be provided if necessary to extend the existing existing Honeywell N4 system from the existing building JACE controller in the theater basement mechanical room.
b. Controls shall be BTL listed.
c. All controllers must be Niagara based of the latest firmware with open license provided to owner for future warranty and service.
1) Provide administrator level username and password for owner so that they may access administrator level functions and configurations.
2) Provide administrator level username and password for any contractor via the owner so that they may access administrator level functions and configurations.
3) Provide audit trail for any administrator level user to provide the owner and initial installing contractor a history of changes for security and liability. This shall be at the discretion of the installing contractor during the warranty period.
d. All binary/digital outputs must have LED status.
e. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
f. Provide sufficient memory to support controller's operating system, database, and programming requirements.
g. Share data between networked controllers.

h. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
i. Utilize real-time clock for scheduling.
j. Continuously check processor status and memory circuits for abnormal operation.
k. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
l. Communication with other network devices to be based on assigned protocol.
m. Monitor, control, or address data points. Mix shall include analog inputs, analog outputs, pulse inputs, pulse outputs and discrete inputs/outputs, as required.
n. Provide control unit's with minimum 30 percent spare capacity.
o. Point Scanning: Set scan or execution speed of each point to operator selected time from 1 to 250 seconds.
p. Upload/Download Capability: Download from or upload to operator station. Upload/Download time for entire control unit database maximum 10 seconds on hard wired LAN, or 60 seconds over voice grade phone lines.
q. Controller perform in stand-alone mode:
    1) Start/stop.
    2) Duty cycling.
    3) Automatic Temperature Control.
    4) Demand control via a sliding window, predictive algorithm.
    5) Event initiated control.
    6) Calculated point.
    7) Scanning and alarm processing.
    8) Full direct digital control.
    9) Trend logging.
    10) Global communications.
    11) Maintenance scheduling.
r. Controller Input/Output Capability:
    1) Discrete/digital input (contact status).
    2) Discrete/digital output.
    3) Analog input.
    4) Analog output.
    5) Pulse input (5 pulses/second).
    6) Pulse output (0-655 seconds in duration with 0.01 second resolution).
s. Controller Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment. In test mode:
    1) Inhibit scanning and calculation of input points. Issue manual control to input points (set analog or digital input point to operator determined test value) from work station.
    2) Control output points but change only data base state or value; leave external field hardware unchanged.

3) Enable control actions on output points but change only data base state or value.

t. Controller local display and adjustment panel: Portable control unit, containing digital display, and numerical keyboard. Display and adjust:
1) Input/output point information and status.
2) Controller set points.
3) Controller tuning constants.
4) Program execution times.
5) High and low limit values.
6) Limit differential.
7) Set/display date and time.
8) Control outputs connected to the network.
9) Automatic control outputs.
10) Perform control unit diagnostic testing.
11) Points in "Test" mode.

2. Communication:
a. Controller to reside on a BACnet network using ISO 8802-3 (ETHERNET) Data Link/Physical layer protocol.
b. Perform routing when connected to a network of custom application and application specific controllers.
c. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

3. Anticipated Environmental Ambient Conditions:
a. Outdoors and/or in Wet Ambient Conditions:
1) Mount within waterproof enclosures.
2) Rated for operation at 40 to 150 degrees F.
b. Conditioned Space:
1) Mount within dustproof enclosures.
2) Rated for operation at 32 to 120 degrees F.

4. Local Keypad and Display for each Controller:
a. Use for interrogating and editing data.
b. System security password prevents unauthorized use.

5. Provisions for Serviceability:
a. Diagnostic LEDs for power, communication, and processor.
b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

6. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.

7. Power and Noise Immunity:
a. Maintain operation at 90 to 110 percent of nominal voltage rating.
b. Perform orderly shutdown below 80 percent of nominal voltage.
c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

C. Custom Application Controllers
1. General:
a. Provide sufficient memory to support controller's operating system, database, and programming requirements.
b. Share data between networked, microprocessor based controllers.

c. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
d. Utilize real-time clock for scheduling.
e. Continuously check processor status and memory circuits for abnormal operation.
f. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
g. Communication with other network devices to be based on assigned protocol.

2. Communication:
a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
b. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

3. Anticipated Environmental Ambient Conditions:
a. Outdoors and/or in Wet Ambient Conditions:
1) Mount within waterproof enclosures.
2) Rated for operation at 40 to 150 degrees F.
b. Conditioned Space:
1) Mount within dustproof enclosures.
2) Rated for operation at 32 to 120 degrees F.

4. Local Keypad and Display for each Controller:
a. Use for interrogating and editing data.
b. System security password prevents unauthorized use.

5. Provisions for Serviceability:
a. Diagnostic LED's for power, communication, and processor.
b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

6. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.

7. Power and Noise Immunity:
a. Maintain operation at 90 to 110 percent of nominal voltage rating.
b. Perform orderly shutdown below 80 percent of nominal voltage.
c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

D. Application Specific Controllers

1. General:
a. Not fully user programmable, microprocessor based controllers dedicated to control specific equipment.
b. Customized for operation within the confines of equipment served.
c. Communication with other network devices to be based on assigned protocol.

2. Communication:
a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
b. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

3. Anticipated Environmental Ambient Conditions:
    a. Outdoors and/or in Wet Ambient Conditions:
        1) Mount within waterproof enclosures.
        2) Rated for operation at 40 to 150 degrees F.
    b. Conditioned Space:
        1) Mount within dustproof enclosures.
        2) Rated for operation at 32 to 120 degrees F.
4. Local Keypad and Display for each Controller:
    a. Use for interrogating and editing data.
    b. System security password prevents unauthorized use.
5. Provisions for Serviceability:
    a. Diagnostic LEDs for power, communication, and processor.
    b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
6. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
7. Power and Noise Immunity:
    a. Maintain operation at 90 to 110 percent of nominal voltage rating.
    b. Perform orderly shutdown below 80 percent of nominal voltage.
    c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 feet.

E. Input/Output Interface
1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.
2. All Input/Output Points:
    a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
    b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
3. Binary Inputs:
    a. Allow monitoring of On/Off signals from remote devices.
    b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
    c. Sense dry contact closure with power provided only by the controller.
4. Pulse Accumulation Input Objects: Comply with all requirements of binary input objects and accept up to 10 pulses per second.
5. Analog Inputs:
    a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
    b. Compatible with and field configurable to commonly available sensing devices.
6. Binary Outputs:
    a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
    b. Outputs provided with three position (On/Off/Auto) override switches.

c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.

7. Analog Outputs:
   a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
   b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
   c. Drift to not exceed 0.4 percent of range per year.
   d. Adjust range of analog output to match range of end device, valves actuator, VFC, etc.
   e. Program all PID loop control to match range and stroke of end device. For example if a VFC has a minimum speed of 20% output should be configure to start at 20% to eliminate spooling of PID outside actual operating range of end device.
   f. Graphics shall represent actual range of end device. If VFC range is from 20% to 100%, graphical reference should match.
8. Tri State Outputs:
   a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
   b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
      1) VAV terminal units.
      2) Duct mounted heating coils.
   c. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
9. System Object Capacity:
   a. System size to be expandable to twice the number of input output objects required by providing additional controllers, including associated devices and wiring.
   b. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

2.5 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies:
1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
2. Limit connected loads to 80 percent of rated capacity.
3. Match DC power supply to current output and voltage requirements.
4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
7. Operational Ambient Conditions: 32 to 120 degrees F.

8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD-810 for shock and vibration.
9. Line voltage units UL recognized and CSA approved.

B. Power Line Filtering:
1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
2. Minimum surge protection attributes:
a. Dielectric strength of 1000 volts minimum.
b. Response time of 10 nanoseconds or less.
c. Transverse mode noise attenuation of 65 dB or greater.
d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

C. Control Unit Battery Back-up:
1. For minimum of 48 hours for complete system including RAM without interruption, with automatic battery charger.

2.6 LOCAL AREA NETWORK (LAN)

A. Provide communication between control units over local area network (LAN).

B. LAN Capacity: Not less than 60 stations or nodes.

C. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.

D. LAN Data Speed: Minimum 19.2 Kb.

E. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.

F. Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.

G. Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

2.7 SYSTEM SOFTWARE

A. General:
1. Include all software required to service, program, graphic creation, and alarming in user interface accessible by owner.

B. Operating System:
1. Concurrent, multi-tasking capability.
a. Common Software Applications Supported: Microsoft Excel.
2. System Graphics:

a. Verify all point naming for graphic mapping, alarming, and notification with owner.
b. Provide a software package to enable the operator to configure, modify, and delete system graphics.
c. System graphics shall appear on the operator workstation monitor complete with all associated data within five seconds of the completion of the operator entry/menu selection.
d. Real time data shall be superimposed on the system graphics and shall be updated at intervals between 10 and 20 seconds. The data shall be positioned on the display at points indicative of the instrumentation locations on the system.
e. Provide a library of commonly used symbols based on ASHRAE and ISA standards.
f. Graphics shall represent actual range of end device. Example: If VFC range is from 20% to 100%, graphical reference should match.
g. Allow up to 10 graphic screens, simultaneously displayed for comparison and monitoring of system status.
h. Animation displayed by shifting image files based on object status.
i. Provide method for operator with password to perform the following:
    1) Move between, change size, and change location of graphic displays.
    2) Modify on-line.
    3) Add, delete, or change dynamic objects consisting of:
        (a) Analog and binary values.
        (b) Dynamic text.
        (c) Static text.
        (d) Animation files.

3. Custom Graphics Generation Package:
    a. Create, modify, and save graphic files and visio format graphics in PCX formats.
    b. HTML graphics to support web browser compatible formats.
    c. Capture or convert graphics from AutoCAD.
4. Standard HVAC Graphics Library:
    a. HVAC Equipment:
        1) Packaged Rooftop Air Handling Units.
        2) Packaged Split System Air Handling Units.
        3) Variable Air Volume Terminal Units.
    b. Ancillary Equipment:
        1) Dampers.
        2) Ductwork.
5. Dynamic Color Graphic Displays:
    a. Up to Sixty (60) outputs of real time, live dynamic data per graphic.
    b. Dynamic graphic data.
    c. Modify graphic screen refresh rate between 1 and 60 seconds.
6. Provide system graphics for, at minimum, each of the following:
    a. Each floor of the building shall indicate the terminal unit zones. Separate the floor graphics into logical areas if the size of the floor is such that the presentation of data is not easily readable. Indicate the following for each zone:

1) Red Background: Space temperature above alarm limit.
2) Green Background: Space temperature within alarm limits.
3) Blue Background: Space temperature below alarm limit.
4) Space temperature superimposed on each zone area.

b. Separate graphic for each terminal unit, which shall incorporate all operator changeable parameters and all input, output, and calculated values.

c. A one-line graphic for all electrical systems indicating status of main equipment and monitored points.

7. The hierarchy of system graphics shall enable an operator to progress from a diagram of the building to a particular floor in the building and to a particular zone on the floor. The selection at each stage shall be by cursor control using a mouse or keyboard arrow buttons.

8. Provide target boxes on displays to enable easy access from one display to a related display. For example, provide a target box on the system diagram for a group of terminal units that will enable one-step access to the associated air handling unit.

9. Submit a complete set of the proposed system graphics in color at the shop drawing stage of the project.

10. Modify the system graphics as requested by the Owner and Consultant following shop drawing review at no additional cost to the Owner.

11. All large complicated graphics containing many data points shall be broken into more readable sections with easy access or arrows to each section.

C. Workstation System Applications:

1. Automatic System Database Save and Restore Functions:
   a. Current database copy of each Building Controller is automatically stored on hard disk.
   b. Automatic update occurs upon change in any system panel.
   c. In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.

2. Manual System Database Save and Restore Functions by Operator with Password Clearance:
   a. Save database from any system panel.
   b. Clear a panel database.
   c. Initiate a download of a specified database to any system panel.

3. Software provided allows system configuration and future changes or additions by operators under proper password protection.

4. On-line Help:
   a. Context-sensitive system assists operator in operation and editing.
   b. Available for all applications.
   c. Relevant screen data provided for particular screen display.
   d. Additional help available via hypertext.

5. Security:
   a. Operator log-on requires user name and password to view, edit, add, or delete data.
   b. System security selectable for each operator.

c. System supervisor sets passwords and security levels for all other operators.
d. Operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
e. Automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
f. All system security data stored in encrypted format.

6. System Diagnostics:
   a. Operations Automatically Monitored:
      1) Workstations.
      2) Printers.
      3) Modems.
      4) Network connections.
      5) Building management panels.
      6) Controllers.
   b. Device failure is annunciated to the operator.
7. Alarm Processing:
   a. All system objects are configurable to "alarm in" and "alarm out" of normal state.
   b. Configurable Objects:
      1) Alarm limits.
      2) Alarm limit differentials.
      3) States.
      4) Reactions for each object.
8. Alarm Messages:
   a. Descriptor: English language.
   b. Recognizable Features:
      1) Source.
      2) Location.
      3) Nature.
9. Configurable Alarm Reactions by Workstation and Time of Day:
   a. Logging.
   b. Printing.
   c. Starting programs.
   d. Displaying messages.
   e. Dialing out to remote locations.
   f. Paging.
   g. Providing audible annunciation.
   h. Displaying specific system graphics.
10. Custom Trend Logs:
    a. Definable for any data object in the system including interval, start time, and stop time.
    b. Trend Data:
       1) Sampled and stored on the building controller panel.
       2) Archivable on hard disk.
       3) Retrievable for use in reports, spreadsheets and standard database programs.
       4) Archival on LAN accessible storage media including hard disk, tape, Raid array drive, and virtual cloud environment.

5) Protected and encrypted format to prevent manipulation, or editing of historical data and event logs.

11. Alarm and Event Log:
    a. View all system alarms and change of states from any system location.
    b. Events listed chronologically.
    c. Operator with proper security acknowledges and clears alarms.
    d. Alarms not cleared by operator are archived to the workstation hard disk.
12. Object, Property Status and Control:
    a. Provide a method to view, edit if applicable, the status of any object and property in the system.
    b. Status Available by the Following Methods:
        1) Menu.
        2) Graphics.
        3) Custom Programs.
13. Reports and Logs:
    a. Reporting Package:
        1) Allows operator to select, modify, or create reports.
        2) Definable as to data content, format, interval, and date.
        3) Archivable to hard disk.
    b. Real-time logs available by type or status such as alarm, lockout, normal, etc.
    c. Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
    d. Set to be printed on operator command or specific time(s).
14. Reports:
    a. Standard:
        1) Objects with current values.
        2) Current alarms not locked out.
        3) Disabled and overridden objects, points and SNVTs.
        4) Objects in manual or automatic alarm lockout.
        5) Objects in alarm lockout currently in alarm.
        6) Logs:
            (a) Alarm History.
            (b) System messages.
            (c) System events.
            (d) Trends.
    b. Custom:
        1) Daily.
        2) Weekly.
        3) Monthly.
        4) Annual.
        5) Time and date stamped.
        6) Title.
        7) Facility name.
    c. Tenant Override:
        1) Monthly report showing total, requested, after-hours HVAC and lighting services on a daily basis for each tenant.
        2) Annual report showing override usage on a monthly basis.
    d. Electrical, Fuel, and Weather:

1) Electrical Meter(s):
   (a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
   (b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.
2) Fuel Meter(s):
   (a) Monthly showing daily natural gas consumption for each meter.
   (b) Annual summary showing monthly consumption for each meter.
3) Weather:
   (a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.

D. Workstation Applications Editors:
1. Provide editing software for each system application at PC workstation.
2. Downloaded application is executed at controller panel.
3. Full screen editor for each application allows operator to view and change:
   a. Configuration.
   b. Name.
   c. Control parameters.
   d. Set-points.
4. Scheduling:
   a. Monthly calendar indicates schedules, holidays, and exceptions.
   b. Allows several related objects to be scheduled and copied to other objects or dates.
   c. Start and stop times adjustable from master schedule.
5. Custom Application Programming:
   a. Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.
   b. Programming Features:
      1) English oriented language, based on BASIC, FORTRAN, C, or PASCAL syntax allowing for free form programming.
      2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
      3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
      4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
      5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.
      6) Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations

(EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.

8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values cab be used in IF/THEN comparisons, calculations, programming statement logic, etc.

9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

2.8 CONTROLLER SOFTWARE

A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.

B. System Security:
   1. User access secured via user passwords and user names.
   2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
   3. User Log On/Log Off attempts are recorded.
   4. Automatic Log Off occurs following the last keystroke after a user defined delay time.

C. Object or Object Group Scheduling:
   1. Automatically initiate equipment or system commands, based on preselected time schedule for points specified.
   2. Provide program times for each day of week, per point, with one minute resolution.
   3. Automatically generate alarm output for points not responding to command.
   4. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.
   5. Weekly Schedules Based on Separate, Daily Schedules:
      a. Include start, stop, optimal stop, and night economizer.
      b. 10 events maximum per schedule.
      c. Start/stop times adjustable for each group object.
   6. Exception Schedules:
      a. Based on any day of the year.
      b. Defined up to one year in advance.
      c. Automatically discarded and replaced with standard schedule for that day of the week upon execution.
   7. Holiday or Special Schedules:
      a. Capability to define up to 99 schedules.
      b. Repeated annually.

c. Length of each period is operator defined.

D. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.

E. Alarms:
1. Verify the following with owner: degree of alarming, event log - item is entered into event with no warning or notification, system alarm - entered into event log with local alarm or warning message, no notification, critical alarm - enters event log, alarms at local machines, and a notification is sent, event “delays” - inform secondary recipients if primary does not acknowledge, “round robin” if required by owner, if alarm is not acknowledged by primary, secondary is notified after delay, if secondary does not acknowledge, primary will be notified again, not stopping until acknowledged.
2. Alarm acknowledgment may be accompanied by note by operator to be entered into event log for archive and information sharing with operators.
3. Off normal condition: Cause alarm and appropriate message, including time, system, point descriptor, and alarm condition. Select alarm state/value and which alarms shall cause automatic dial-out.
4. Critical alarm or change-of-state: Display message, stored on disk for review and sort, or print.
5. Display multiple alarms in order of occurrence.
6. Define time delay for equipment start-up or shutdown.
7. Continue to indicate unacknowledged alarms after return to normal.
8. Binary object is set to alarm based on the operator specified state.
9. Analog object to have high/low alarm limits.
10. All alarming is capable of being automatically and manually disabled.
11. Alarm Messages:
    a. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totalized point's warning limit, hardware elements advisories.
    b. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.
12. Alarm Reporting:
    a. Operator determines action to be taken for alarm event.
    b. Alarms to be routed to appropriate workstation.
    c. Reporting Options:
        1) Start programs.
        2) Print.
        3) Logged.
        4) Custom messaging.
        5) Graphical displays.
        6) Dial out to workstation receivers via system protocol.

F. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.
1. Maintenance scheduling targets with automatic annunciation, scheduling and shutdown.

2. Equipment safety targets.
3. Display of maintenance material and estimated labor.
4. Target point reset, per point.

G. Advisories:
1. Summary which contains status of points in locked out condition.
2. Continuous operational or not operational report of interrogation of system hardware and programmable control units for failure.
3. Report of power failure detection, time and date.
4. Report of communication failure with operator device, field interface unit, point, programmable control unit.

H. Sequencing: Application software based upon specified sequences of operation in Section 23 09 93.

I. PID Control Characteristics:
1. Direct or reverse action.
2. Anti-windup.
3. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
4. User selectable controlled variable, set-point, and PED gains.

J. Staggered Start Application:
1. Prevents all controlled equipment from simultaneously restarting after power outage.
2. Order of equipment startup is user selectable.

K. Anti-Short Cycling:
1. All binary output objects protected from short-cycling.
2. Allows minimum on-time and off-time to be selected.

L. On-Off Control with Differential:
1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.

M. Run-Time Totalization:
1. Totalize run-times for all binary input objects.
2. Provides operator with capability to assign high run-time alarm.

N. Trend Point:
1. Sample up to ____ points, real or computed, with each point capable of collecting ____ samples at intervals specified in minutes, hours, days, or month.
2. Output trend logs as line graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique pattern, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

O. Interlocking:
   1. Permit events to occur, based on changing condition of one or more associated master points.
   2. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.
   3. Operator commands:
      a. Define single master/multiple master interlock process.
      b. Define logic interlock process.
      c. Lock/unlock program.
      d. Enable/disable interlock process.
      e. Execute terminate interlock process.
      f. Request interlock type summary.

P. Input/Output Capability From Operator Work Station:
   1. Request display of current values or status in tabular or graphic format.
   2. Command selected equipment to specified state.
   3. Initiate logs and reports.
   4. Change analog limits.
   5. Add, delete, or change points within each control unit or application routine.
   6. Change point input/output descriptors, status, alarm descriptors, and engineering unit descriptors.
   7. Add new control units to system.
   8. Modify and set up maintenance scheduling parameters.
   9. Develop, modify, delete or display full range of color graphic displays.
   10. Automatically archive select data even when running third party software.
   11. Provide capability to sort and extract data from archived files and to generate custom reports.
   12. Support two printer operations.
      a. Alarm printer: Print alarms, operator acknowledgements, action messages, system alarms, operator sign-on and sign-off.
      b. Data printer: Print reports, page prints, and data base prints.
   13. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
   14. Print selected control unit data base.

Q. Data Base Creation and Support: Changes shall utilize standard procedures. Control unit shall automatically check work station data base files upon connection and verify data base match. Minimum capability shall include:
   1. Add and delete points.
   2. Modify any point parameter.
   3. Change, add, or delete English language descriptors.
   4. Add, modify, or delete alarm limits.
   5. Add, modify, or delete points in start/stop programs, trend logs, etc.
   6. Create custom relationship between points.
   7. Create or modify DDC loops and parameters.
   8. Create or modify override parameters.
   9. Add, modify, and delete any applications program.
   10. Add, delete, develop, or modify dynamic color graphic displays.

R. Operator Station:
   1. Accept data from LAN as needed without scanning entire network for updated point data.
   2. Interrogate LAN for updated point data when requested.
   3. Allow operator command of devices Without the purchase of additional software from any pc via web interface..
   4. Allow operator to place specific control units in or out of service.
   5. Allow parameter editing of control units.
   6. Store duplicate data base for every control unit and allow down loading while system is on line.
   7. Control or modify specific programs.
   8. Develop, store and modify dynamic color graphics.
   9. Provide data archiving of assigned points and support overlay graphing of this data utilizing up to four (4) variables.

S. Event Processing: Automatically initiate commands, user defined messages, take specific control actions or change control strategy and application programs resulting from event condition. Event condition may be value crossing operator defined limit, change-of-state, specified state, or alarm occurrence or return to normal.

T. Automatic Restart: Automatically restart field equipment on restoration of power. Provide time delay between individual equipment restart and time of day start/stop.

U. Messages:
   1. Automatically display or print user-defined message subsequent to occurrence of selected events.
   2. Compose, change, or delete any message.
   3. Display or log any message at any time.
   4. Assign any message to any event.

V. Reports:
   1. Manually requested with time and date.
   2. Long term data archiving to hard disk.
   3. Automatic directives to download to transportable media such as floppy diskettes for storage.
   4. Data selection methods to include data base search and manipulation.
   5. Data extraction with mathematical manipulation.
   6. Data reports shall allow development of XY curve plotting, tabular reports (both statistical and summary), and multi-point timed based plots with not less than four (4) variables displayed.
   7. Generating reports either normally at operator direction, or automatically under work station direction.
   8. Reports may either manually displayed or printed, or may be printed automatically on daily, weekly, monthly, yearly or scheduled basis.
   9. Include capability for statistical data manipulation and extraction.
   10. Provide capability to generate four types of reports: Statistical detail reports, summary reports, trend graphic plots, x-y graphic plots.

W. Parameter Save/Restore: Store most current operating system, parameter changes, and modifications on disk or diskette.

X. Data Collection:
1. Automatically collect and store in disk files.
2. Daily electrical energy consumption, peak demand, and time of peak demand for up to electrical meters over 2 year period.
3. Daily billable electrical energy consumption and time for up to 1024 zones over a 10 year period.
4. Provide archiving of stored data for use with system supplied custom reports.
5. Generate, store, and retrieve library symbols.
6. Single or double height characters.
7. Sixty (60) dynamic points of data per graphic page.
8. Animated graphics for discrete points.
9. Analog bar graphs.
10. Display real time value of each input or output line diagram fashion.

2.9 HVAC CONTROL PROGRAMS

A. General:
1. Support Inch-pounds and SI (metric) units of measurement.
2. Identify each HVAC Control system.

B. Optimal Run Time:
1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
4. Use outside air temperature to determine early shut down with ventilation override.
5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.2 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

B. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.

C. Provide interfaces between all equipment/systems and BMCS as indicated.

D. Provide local UPS power supplies for all system panels and equipment.

E. Provide conduit and electrical wiring in accordance with Section 26 05 83. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

3.3 MANUFACTURER'S FIELD SERVICES

A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

B. Provide service engineer to instruct Owner's representative in operation of systems plant and equipment for 3 day period.

C. Provide basic operator training for up to 10 persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Include a minimum of 12 hours dedicated instructor time. Provide training on site.

3.4 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate complete and operating system to Owner.

END OF SECTION

SECTION 23 09 93

SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.

B. Sequence of operation for:
   1. Air terminal units with remote duct heaters.
   2. Packaged split system air handling unit (variable volume, single zone).
   3. Packaged rooftop (variable volume, supplying air terminal units).

1.2 SYSTEM DESCRIPTION

A. This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.

1.3 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Specification Compliance Review.

C. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
   1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
   2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in Contract Documents.
   3. Include at least the following sequences:
      a. System off.
      b. Start-up.
      c. Warm-up mode.
      d. Normal operating mode.
      e. Unoccupied mode.
      f. Shutdown.
      g. Capacity control sequences and equipment staging.
      h. Temperature and pressure control, such as setbacks, setups, resets, etc.
      i. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
      j. Effects of power or equipment failure with all standby component functions.

k. Sequences for all alarms and emergency shut downs.
l. Seasonal operational differences and recommendations.
m. Interactions and interlocks with other systems.

4. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
5. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.
6. Include schedules, if known.

D. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
1. Label with settings, adjustable range of control and limits.
2. Include flow diagrams for each control system, graphically depicting control logic.
3. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
5. Include all monitoring, control and virtual points specified in elsewhere.
6. Include a key to all abbreviations.

E. Points List: Submit list of all control and monitor points indicating at least the following for each point.
1. Name of controlled system.
2. Point abbreviation.
3. Point description; such as dry bulb temperature, airflow, etc.
4. Display unit.
5. Control point or setpoint (Yes / No); i.e. a point that controls equipment and can have its setpoint changed.
6. Monitoring point (Yes / No); i.e. a point that does not control or contribute to the control of equipment but is used for operation, maintenance, or performance verification.
7. Intermediate point (Yes / No); i.e. a point whose value is used to make a calculation which then controls equipment, such as space temperatures that are averaged to a virtual point to control reset.
8. Calculated point (Yes / No); i.e. a “virtual” point generated from calculations of other point values.

F. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.

1.4 CONTROL SYSTEM INTERFACES

A. System shall fully support a multi-vendor environment and be able to interface and integrate third party systems and sequences via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.

B. System and Equipment to BMCS Interfaces shall be provided for, but not limited to:
   1. Packaged Split System Air-Handling Units.
   2. Packaged Roof-Top Units.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 OPERATING SEQUENCES - GENERAL

A. Sequence of Control indicated illustrates basic control function only. Provide all control devices required for controlling air handling units, exhaust fans, physical plant equipment, terminal equipment, and all related items. Provide monitoring only devices as indicated.

B. The Control Contractor shall perform the initial input of all required operational data for each point that is to be used based on information supplied to the Contractor by the Owner. The Contractor shall assist the Owner's staff in developing the schedule and shall demonstrate the operation of the system using the data.

C. Provide adequate English language notation in the software to assist the operator in understanding the intent of the programmed sequences.

D. The Control Contractor shall be responsible for the stable operation of all control loops. If the Control Contractor has not provided self-tuning PID control algorithms then the Control Contractor shall manually tune all control loops. Verify all control loops are stable whether or not they are self-tuning.

E. The Control Contractor shall provide any modifications to the operating sequence programs as requested by the Owner without additional costs until the final acceptance of the entire control system.

F. Graphics shall represent actual range of outputs.

3.2 NIGHT (UNOCCUPIED) SETBACK - SETUP

A. Provide a software program that shall:
   1. Start HVAC equipment after normal hours of scheduled operation to maintain building after-hour setpoints, while reducing energy consumption.
   2. Night setback temperatures for heating shall be initially set at 55 degrees F to activate the heating equipment and 60 degrees F to stop the heating equipment. Once activated, the units involved shall operate as specified in the respective sequence of operation. Coordinate the operation of this program with the requirements for terminal unit controls.
   3. Night setup temperatures for cooling shall be initially set at 90 degrees F to activate the cooling equipment and 85 degrees F to stop the cooling equipment. Once activated, the units involved shall operate as specified in the respective

sequence of operation. Coordinate the operation of this program with the requirements for terminal unit controls.

B. The operator shall be able to implement this function for all HVAC equipment using an interactive procedure on an individual or group-controlled basis.

C. The operator shall be able to assign minimum run times for each piece of equipment.

D. The operation of this program shall be disabled when the outside air temperature is outside operator defined limits, initially set at 35 degrees F and 95 degrees F.

E. A report shall be available on demand and on a scheduled basis, which provides the following information:
   1. Night setback/setup setpoints and associated equipment.

F. This feature shall only be implemented for equipment in the BMCS software control mode.

G. Setpoints for each associated piece of equipment shall be displayed on the associated system display graphics. Setpoints shall be changeable via the graphical display.

H. The current status of night setback - setup modes shall be indicated on the associated system graphic.

3.3 OPTIMIZED SCHEDULING

A. Provide an adaptive software program that shall:
   1. Start HVAC equipment at the latest possible time while ensuring that space in the building reaches setpoint conditions by the time occupancy commences.
   2. Stop HVAC equipment at the earliest possible time while ensuring that space in the building shall still be within the setpoint deadband at the scheduled end of occupancy.

B. The operator shall be able to implement this function for each group of terminal units and other HVAC equipment using an interactive procedure. A group of terminal units shall comprise all the terminal units on the same floor of the tower served by the same air handling unit. The operator shall be able to assign start of occupancy and end of occupancy times for each day of the week and for holidays. A separate Monday schedule should be provided for earlier start times.

C. This program shall base the determined equipment start and stop times on monitored data such as space temperatures within the area served by the equipment and ambient conditions. If the BMCS subcontractor requires information other than that provided by the monitoring detailed in the Field Termination Schedules, then the necessary additional instrumentation shall be provided within the base bid price.

D. The operator shall be able to assign limits to the start and stop times. Initially these limits shall be set as follows:
   1. BMCS determined start times shall not be more than three hours before the scheduled occupancy.

2. BMCS determined stop times shall not be more than one hour before the scheduled end of occupancy.

E. A report shall be available on demand and on a scheduled basis, which provides the following information:
1. Occupancy schedules.
2. Time of last equipment start and space conditions at scheduled occupancy time.
3. Time of last equipment stop and space conditions at scheduled end of occupancy time.

F. This feature shall only be implemented for equipment in the BMCS software control mode.

3.4 AIR TERMINAL UNITS

A. Single-Duct Variable Volume with Remote Electric Duct Heaters:
1. System Off - When the system is off:
a. The primary air damper shall be closed.
b. The heating shall be off.
2. Initiation of System Start-Up - The system shall be started:
a. Manually initiated by operator through BMCS.
b. Automatically by BMCS through occupancy schedule.
3. System Operation (Dual Maximum Control Strategy) - After system start-up has been initiated the following shall occur:
a. The primary air damper shall modulate to vary the supply airflow between the scheduled minimum and maximum primary cooling airflows to maintain the space cooling temperature setpoint.
b. When the space temperature falls below the space heating temperature setpoint the following shall occur:
1) The primary air damper shall modulate to supply the scheduled minimum heating primary air flow rate.
2) The air terminal unit controller shall modulate the remote electric duct heater to maintain the space heating temperature setpoint.
3) The discharge air temperature sensor shall limit discharge air temperature to no more than 20 degrees above space setpoint.
4) Upon further call for heating, the primary air damper shall modulate to supply up to the maximum scheduled heating primary air flow rate. During this time, the air terminal unit controller shall modulate the remote electric duct heater to maintain the heating supply air temperature setpoint (85 degrees F, adjustable).
4. A2L Refrigerant Leak Detection Mode:
a. Shall be initiated as follows: Automatically in response to an enabled hardwired alarm relay from the A2L refrigerant leak detector(s) which is/are factory-provided in the packaged rooftop air handler. The alarm relay shall be hard-wired (daisy-chained) to the remote enable terminals of all electric duct heaters controlled by variable volume terminal units.
b. Upon refrigerant leak detection and as long as the A2L refrigerant leak detector(s) continues to detect refrigerant in the airstream, the electric

heating coils of all duct heaters controlled by variable volume terminal units shall be de-energized. During this time, heating control signals from the terminal unit controllers shall be ignored.

c. Upon refrigerant leak detection and as long as the A2L refrigerant leak detector(s) continues to detect refrigerant in the airstream, the dampers of all terminal units shall also modulate to full open.

d. An alarm notification shall be sent to the specified facilities contact personnel indicating that the variable air volume terminal units are in refrigerant leak detection mode.

e. When the A2L refrigerant leak detector(s) no longer detect refrigerant, the variable air volume terminal units shall resume normal operation.

1) Note: The packaged rooftop air handler onboard controls also respond to feedback from the A2L refrigerant leak detector(s) and may have alarms/faults after a leak incident that will prohibit normal operation of the variable air volume terminal unit system until repair service has been initiated.

5. System Shutdown - Shall be initiated as follows:
   a. Manually initiated by operator through BMCS.
   b. Automatically by BMCS through occupancy schedule.
6. System Setpoints - The setpoints shall be operator changeable and initially set as follows:
   a. Space cooling temperature setpoint shall be 74 degrees F.
   b. Space heating temperature setpoint shall be 70 degrees F.
   c. The minimum and maximum primary air flow setpoints shall be set to the design airflow setpoints as indicated in the contract documents.
   d. The high and low temperature setpoints shall be set initially at 2 degrees F above/below the temperature setpoints.
   e. The occupant shall have the capability to adjust the space temperature setpoint through the space temperature sensor.
   f. The programming shall limit user adjustment to + or - 2 degrees F of the base setpoint.
7. Alarms - The BMCS shall generate an alarm for the following conditions:
   a. High temperature.
   b. Low temperature.
8. Points List:
   a. Analog Inputs:
      1) Primary air flow.
      2) Space temperature.
      3) Space temperature setpoint adjust.
      4) Discharge air temperature.
   b. Analog Outputs:
      1) Primary air damper.
      2) Heating electric coil controller.

3.5 PACKAGED ROOFTOP UNIT (VARIABLE VOLUME, SINGLE ZONE)

A. NOTE: The sequence of operation below is a generic representation of the proprietary sequence programmed in the manufacturer's onboard controller. It is not intended to override any operations of the the manufacturer's sequence. The building management

control system (BMCS) will only interact with the manufacturer's sequence via the readable and writeable points available via the controller's software BACnet interface.

B. System Off - When the system is off:
   1. The outside air damper shall be closed.
   2. The return air damper shall be open.
   3. Supply fan shall be off.
   4. DX cooling shall be off.
   5. Electric heat shall be off.

C. Initiation of System Start-Up - The system shall be started:
   1. Manually initiated by operator through BMCS.
   2. Automatically by BMCS through occupancy schedule.

D. System Operation - After system start-up has been initiated the following shall occur:
   1. The supply fans shall be started at minimum speed. After a time period defined by the manufacturer's controls, the fans shall be enabled for automatic speed control.
   2. The supply fan speed shall modulate according to the manufacturer's single zone variable air volume controls to maintain the supply static pressure setpoint.
   3. Economizer Control:
      a. The manufacturer's economizer controls shall not be used.
   4. CO2-Based Demand Controlled Ventilation: The outside air damper in the remote mixing box shall modulate to the outside air damper opening percentage setpoint according to the manufacturer's controls. The damper position setpoint is calculated according to the manufacturer's controls based on the space CO2 reading, which is measured by the manufacturer provided space CO2 sensor, and the maximum damper opening percentage.
   5. The DX cooling shall modulate according to the manufacturer's controls to maintain the space air temperature set point.
   6. The electric heater shall modulate according to the manufacturer's controls to maintain the space air temperature set point.

E. Dehumidification Mode:
   1. Shall be initiated as follows: Automatically when the relative humidity or dew point in the space rises above the dehumidification set point.
   2. The DX cooling shall modulate according to the manufacturer's controls to maintain the space humidity setpoint.
   3. The electric heating coil shall modulate according to the manufacturer's controls to reheat the dehumidified supply air back to the cooling supply air temperature setpoint.

F. A2L Refrigerant Leak Detection Mode:
   1. Shall be initiated as follows: Automatically in response to feedback from the A2L refrigerant leak detector(s) which is/are factory-provided in the packaged unit.
   2. Upon refrigerant leak detection and as long as the A2L refrigerant leak detector(s) continues to detect refrigerant in the airstream, the electric heating coil shall be deenergized, cooling shall be disabled, and the supply fan shall be modulated to full design speed, according to the manufacturer's controls.

3. When the A2L refrigerant leak detector(s) no longer detect refrigerant, the packaged rooftop unit shall resume normal operation unless prohibited by related faults/warnings, according to the manufacturer's controls.

G. System Shutdown - Shall be initiated as follows:
1. Manually initiated by operator through BMCS.
2. Automatically through occupancy schedule.
3. Automatically in the event of building power failure or fire alarm.

H. System Setpoints - The setpoints shall be operator changeable and initially set as follows:
1. Supply air temperature setpoint shall be 55 degrees F.
2. Space humidity setpoint shall be 50% RH.
3. Supply air pressure setpoint shall be 1.0 inches w.g.
4. Reference enthalpy setpoint shall be 28 Btu/lbda.
5. The minimum and maximum speed signal positions shall be set by the Balancing Contractor within the fan manufacturer's limitations.
6. The maximum outside air flowrate setpoint shall be as scheduled on the Mechanical Drawings.
7. The return air CO2 limit shall be 500 ppm above the ambient CO2 reading (adjustable). This is a dynamically controlled setpoint.
8. The space pressure setpoint shall be 0.05 inches w.g.

I. Alarms - The BMCS shall generate an alarm for the following conditions:
1. Fan failure
2. General RTU failure
3. Heating/Cooling failure

J. Points List:
1. Software Interface - The following points shall be provided through the BACnet interface.
    a. Supply fan speed reference feedback.
    b. Supply fan fault.
    c. General unit alarm.
    d. Unit on/off status.
    e. Heating/cooling status.
    f. Cooling compressor capacity percentage.
    g. Electric heat capacity percentage.
    h. Supply air temperature.
    i. Space humidity setpoint.
    j. Space temperature setpoint.
    k. Space CO2 level.
    l. Return air temperature.
    m. Return air humidity.
    n. Outside air temperature.
    o. Outside air humidity.
    p. Outside air damper position.
    q. Return air damper position.
    r. A2L refrigerant leak detector alarm status.

3.6 PACKAGED ROOFTOP UNIT (VARIABLE VOLUME, SUPPLYING AIR TERMINAL UNITS)

A. NOTE: The sequence of operation below is a generic representation of the proprietary sequence programmed in the manufacturer's onboard controller. It is not intended to override any operations of the the manufacturer's sequence. The building management control system (BMCS) will only interact with the manufacturer's sequence via the readable and writeable points available via the controller's software BACnet interface.

B. System Off - When the system is off:
   1. The relief air dampers shall be closed.
   2. The outside air dampers shall be closed.
   3. The return air dampers shall be open.
   4. Supply fan shall be off.
   5. Power exhaust fan shall be off.
   6. DX cooling shall be off.
   7. Gas heat shall be off.

C. Initiation of System Start-Up - The system shall be started:
   1. Manually initiated by operator through BMCS.
   2. Automatically by BMCS through occupancy schedule.

D. System Operation - After system start-up has been initiated the following shall occur:
   1. The supply fans shall be started at minimum speed. After a time period defined by the manufacturer's controls, the fans shall be enabled for automatic speed control.
   2. The supply fan speed shall modulate according to the manufacturer's controls to maintain the supply static pressure setpoint. Pressure sensor shall be located 2/3 of the distance down the system ductwork.
   3. The relief air damper and power exhaust fan shall modulate to maintain the building static pressure setpoint. The building pressure sensor shall compare the pressure difference between the inside and outside. Outside pressure shall be taken near the front door, low on the building, preferably south, or alternatively east or west sides of the building.
   4. Economizer Control:
      a. Outside and return air dampers shall be modulated inversely proportionate to maintain a mixed air temperature set point approximately 2 deg. (adj.) less than the discharge air set point according to the manufacturer's controls.
      b. If “global” economizer enable is to be used the economizer shall be enabled whenever:
         1) Outside air temperature is less than 55 deg (adj.).
         2) Outside air enthalpy is below 25 btu/lb of dry air with a dead band of 3 btu/lb.
      c. The economizer shall not be used whenever:
         1) It is disabled by the operator through the BMCS interface to the manufacture's controls.
         2) Morning warm-up is enabled.
         3) If return air temperature is below 65 degrees (adj.) unless a “pre-cool” sequence is being used.

5. Minimum outside air damper shall modulate to provide the minimum outdoor airflow, as measured by the factory provided airflow station. The outsider airflow setpoint is calculated according to the manufacturer's controls based on the measured CO2 reading from the BMCS and the maximum outdoor airflow setpoint.
    a. Note: The BMCS shall give the operator the choice of outputting EITHER the highest CO2 reading from all the zone CO2 sensors in the museum spaces served by the packaged rooftop unit (AHU-1 or AHU-2) OR the average of the readings from these sensors to the packaged rooftop units for the purpose of calculating the required outside airflow setpoint.
6. The DX cooling shall modulate according to the manufacturer's controls to maintain a cooling supply air temperature set point.
7. The gas heater shall modulate according to the manufacturer's controls to maintain a heating supply air temperature set point.

E. Dehumidification Mode:
1. Shall be initiated as follows: Automatically when the relative humidity or dew point in the space rises above the dehumidification set point.
2. The DX cooling shall modulate according to the manufacturer's controls to maintain the dehumidification leaving coil air temperature.
3. The hot gas reheat coil shall modulate according to the manufacturer's controls to reheat the dehumidified supply air back to the cooling supply air temperature setpoint.

F. A2L Refrigerant Leak Detection Mode:
1. Shall be initiated as follows: Automatically in response to feedback from the A2L refrigerant leak detector(s) which is/are factory-provided in the packaged rooftop unit.
2. Upon refrigerant leak detection and as long as the A2L refrigerant leak detector(s) continues to detect refrigerant in the airstream, the electric heating coil shall be deenergized, cooling shall be disabled, and the supply fan shall be modulated to full design speed, according to the manufacturer's controls. If required by the manufacturer's control sequence, the economizer and/or power exhaust may be enabled, as well.
3. Upon refrigerant leak detection and as long as the A2L refrigerant leak detector(s) continues to detect refrigerant in the airstream, a hardwired alarm relay from the leak detector or the manufacture's controls shall be enabled. This relay will be hardwired to any and all electric duct heaters in the supply ductwork served by the rooftop unit and will de-energize those duct heaters when enabled.
4. When the A2L refrigerant leak detector(s) no longer detect refrigerant, the packaged rooftop unit shall resume normal operation unless prohibited by related faults/warnings, according to the manufacturer's controls. The hardwired alarm relay will be disabled.

G. System Shutdown - Shall be initiated as follows:
1. Manually initiated by operator through BMCS.
2. Automatically through occupancy schedule.
3. Automatically in the event of building power failure or fire alarm.

H. System Setpoints - The setpoints shall be operator changeable and initially set as follows:
   1. Supply air temperature setpoint shall be 55 degrees F.
   2. Space humidity setpoint shall be 50% RH.
   3. Supply air pressure setpoint shall be 1.0 inches w.g.
   4. Reference enthalpy setpoint shall be 28 Btu/lbda.
   5. The minimum and maximum speed signal positions shall be set by the Balancing Contractor within the fan manufacturer's limitations.
   6. The maximum outside air flowrate setpoint shall be as scheduled on the Mechanical Drawings.
   7. The return air CO2 limit shall be 500 ppm above the ambient CO2 reading. This is a dynamically controlled setpoint.
   8. The space pressure setpoint shall be 0.05 inches w.g.

I. Alarms - The BMCS shall generate an alarm for the following conditions:
   1. Fan failure
   2. General RTU failure
   3. Heating/Cooling failure

J. Points List:
   1. Digital Inputs:
      a. A2L refrigerant leak detector alarm status.
   2. Software Interface - The following points shall be provided through the BACnet interface.
      a. Supply fan speed reference feedback.
      b. Supply fan fault.
      c. Power exhaust speed reference feedback.
      d. General unit alarm.
      e. Unit on/off status.
      f. Heating/cooling status.
      g. Cooling compressor capacity percentage.
      h. Gas heat firing percentage.
      i. Supply air temperature setpoint.
      j. Supply air temperature.
      k. Supply air humidity.
      l. Supply air static pressure setpoint.
      m. Supply air static pressure.
      n. Space humidity setpoint.
      o. Reference enthalpy setpoint.
      p. Return air temperature.
      q. Return air humidity.
      r. Outside air temperature.
      s. Outside air humidity.
      t. Outside air damper position.
      u. Outside airflow.
      v. Return air damper position.
      w. A2L refrigerant leak detector alarm status.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Hydronic system requirements.

B. Equipment drains and overflows.

C. Unions, flanges, mechanical couplings, and dielectric connections.

1.2 CODE AND PERMIT COMPLIANCE

A. Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that indicated shall not be substituted.

B. Contractors shall familiarize themselves with all requirements as to permits, fees, etc., and shall comply. All permits, licenses, inspections, and arrangements required for the work shall be provided by the Contractors at their expense.

C. All utilities shall be installed in accordance with utility company rules and regulations.

D. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of piping systems. Wherever practical, install piping as indicated.

1.3 REFERENCE STANDARDS

A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.

B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

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

D. ASME B31.9 - Building Services Piping.

E. ASTM B32 - Standard Specification for Solder Metal.

F. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

G. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).

H. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.

I. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings.

J. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

K. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast.

L. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.4 SUBMITTALS

A. Product Data:
   1. Include data on pipe materials, pipe fittings, valves, and accessories.
   2. Provide manufacturers catalog information.
   3. Show grooved joint couplings, fittings, valves, and specialties on drawings and product submittals, specifically identified with the manufacturer's style or series designation.

B. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

C. Pipe pressure testing report.

D. Mechanical grooved joint couplings, fittings and specialties shall be shown on shop drawings and product submittals, and shall be specifically identified with the manufacturer’s style or series designation.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.

B. Installer Qualifications: Company specializing in performing work of the type specified in this sectionwith minimum 5 years of experience.

C. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.

D. Date stamp all castings used for coupling housings, fittings, valve bodies, etc. for quality assurance and traceability.

E. Coupling Manufacturer:
   1. Perform on-site training by factory-trained representative to the Contractor's field personnel in the proper use of grooving tools and installation of grooved joint products.
   2. Periodic job site visits by factory-trained representative to ensure best practices in grooved joint installation.

F. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

G. All grooved joint couplings, fittings and specialties shall be the products of a single manufacturer.

1. Grooving tools shall be of the same manufacturer as the grooved components.
2. All castings used for coupling housings, fittings, etc., shall be date stamped for quality assurance and traceability.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.7 FIELD CONDITIONS

A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.1 HYDRONIC SYSTEM REQUIREMENTS

A. Comply with ASME B31.9 and applicable federal, state, and local regulations.

B. Piping: Provide piping, fittings, hangers, and supports as required, as indicated, and as follows:
1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
3. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.

C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use unions to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
1. Where grooved joints are used in piping, provide grooved valve/equipment connections if available; if not available, provide flanged ends and grooved flange adapters.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn; using one of the following joint types:
1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
2. Mechanical Press Sealed Fittings: Double pressed type complying with ASME B16.22, utilizing EPDM, non toxic synthetic rubber sealing elements..

2.3 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe of 2 Inches and Less:
1. Copper Pipe: Bronze, soldered joints.

B. Pressed Fittings:
1. Copper Tube:
a. Copper and copper alloy press fitting shall conform to material requirements of ASME B16.18 or ASME 16.22 AND Performance criteria of IAPMO PS 117.
b. Sealing elements shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by the fitting manufacturer.
c. On sizes 1/2" to 4" the fitting shall have a feature that assures leakage of liquids and/or gases from inside the system past the sealed elementof an unpressed connection. this function feature shall provide an easy indication of an unsealed connection.

C. Dielectric Connections:
1. **Dielectric unions shall not be used.**
2. Waterways and Nipples:
a. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F
3. Flanges:
a. Dielectric flanges with same pressure ratings as standard flanges.
b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
c. Dry insulation barrier able to withstand 600-volt breakdown test.
d. Construct of galvanized steel with threaded end connections to match connecting piping.
e. Suitable for the required operating pressures and temperatures.
f. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
4. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 degrees F.

D. Joining Materials:
1. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.
2. 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.

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment using jointing system specified.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.2 INSTALLATION

A. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

B. Install and support in accordance with manufacturer's instructions.

C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and to avoid interference with use of space.

E. Group piping whenever practical at common elevations.

F. Sleeve pipe passing through partitions, walls, and floors.

G. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.

H. Slope piping and arrange to drain at low points.

I. Anchor piping for proper direction of expansion and contraction.

J. Piping shall be installed so as to allow removal of ceiling hung equipment.

K. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. See Section 23 07 19.

3.3 EQUIPMENT DRAINS AND OVERFLOW

A. Piping material shall be suitable for type and temperature of drainage and location of equipment. Size piping per manufacturer's requirements and as indicated.

B. Cooling coil condensate drainage shall be copper pipe. Condensate drain piping size (unless indicated otherwise):
   1. Air Handling Units and Rooftop Units:
      a. Less than 30 tons: 1 1/4"
      b. 31 - 50 tons: 1 1/2"
      c. 51 - 150 tons: 2"
   2. Terminal Cooling, Fan Coil, Blower Coil and Furnaces:
      a. 0 - 5 tons: 3/4"
      b. 6 - 20 tons: 1"

C. Route drains and overflows to nearest floor drain unless shown otherwise. Slope piping to drain at 1/8 inch per foot. Avoid crossing walking paths in mechanical rooms.

3.4 SCHEDULES

A. Hanger Spacing for Copper Tubing.
   1. 1/2 inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1 inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-1/2 inch and 2 inch: Maximum span, 8 feet; minimum rod size, 3/8 inch.

SECTION 23 23 00

REFRIGERANT PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Piping.

B. Refrigerant.

1.2 CODE AND PERMIT COMPLIANCE

A. Work shall be in accordance with all applicable codes. Where the codes and drawings do not agree, the code shall take precedence; however, code shall take precedence over what is shown only when it is more stringent than that indicated. Items that are allowed by codes which are less stringent than that shown on the Drawings shall not be substituted.

B. Contractors shall familiarize themselves with all requirements as to permits, fees, etc., and shall comply. All permits, licenses, inspections, and arrangements required for the work shall be provided by the Contractors at their expense.

C. All utilities shall be installed in accordance with utility company rules and regulations.

D. Drawings, plans, and schematics and diagrams indicate the general location and the arrangement of piping systems. Wherever practical, install piping as indicated.

E. AHRI 730 (I-P) - Flow Capacity Rating of Suction Line Filters and Suction Line Filter Driers.

F. ASHRAE Std 15 - Safety Standard for Refrigeration Systems.

G. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.

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

I. ASME B31.5 - Refrigeration Piping and Heat Transfer Components.

J. ASME B31.9 - Building Services Piping.

K. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

L. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

M. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.

N. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.

O. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

P. MSS SP-69 - Pipe Hangers and Supports - Selection and Application; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.

Q. MSS SP-89 - Pipe Hangers and Supports - Fabrication and Installation Practices; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.

1.3 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Product Data: Provide general assembly of specialties, including manufacturer's catalogue information. Provide manufacturer's catalog data including load capacity.

C. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.

D. Design Data: Submit design data indicating pipe sizing. Indicate load-carrying capacity of trapeze, multiple pipe, and riser support hangers.

E. Test Reports: Indicate results of leak test, acid test.

F. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.

G. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.

H. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 60 00 - Product Requirements, for additional provisions.
   2. Extra Filter-Dryer Core: One spare for each filter-dryer assembly.

1.4 QUALITY ASSURANCE

A. Designer Qualifications: Design piping system under direct supervision of a Professional Engineer experienced in design of this type of work.

B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties in shipping containers with labeling in place.

B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Comply with ASME B31.9 for installation of piping system.

B. Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.

C. Welders Certification: In accordance with ASME BPVC-IX.

D. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

2.2 PIPING

A. Copper Tube: ASTM B280, H58 hard drawn.
   1. Fittings: ASME B16.22 wrought copper.
   2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.

B. Pipe Supports and Anchors:
   1. Provide hangers and supports that comply with MSS SP-58.
      a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
   2. Conform to ASME B31.5.
   3. Hangers for Pipe Sizes 1/2 to 1-5/8 Inch: Carbon steel adjustable swivel, split ring.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
   6. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
   7. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
   8. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
      a. Bases: High density, UV tolerant, polypropylene or reinforced PVC.
      b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
      c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.

d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.

e. Height: Provide minimum clearance of 18 inches under pipe to top of roofing.

f. Manufacturers:

1) Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com.

2) Erico International Corporation: www.erico.com.

3) PHP Systems/Design: www.phpsd.com.

4) Unistrut, a brand of Atkore International Inc: www.unistrut.com.

2.3 REFRIGERANT

A. Refrigerant: R-454B, as defined in ASHRAE Standard 34.

B. Refrigerant: R-32, as defined in ASHRAE Standard 34.

PART 3 EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Install refrigeration specialties in accordance with manufacturer's instructions.

B. Size refrigerant piping per the condensing unit manufacturer's recommendations.

C. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and avoid interference with use of space.

E. Group piping whenever practical at common elevations and locations. Slope piping in the direction of refrigerant flow as recommended by the condensing unit manufacturer.

F. Do not install riser traps in refrigerant piping unless specifically required by the condensing unit manufacturer.

G. Do not install double suction risers unless specifically required by the condensing unit manufacturer.

H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. Provide clearance for installation of insulation and access to valves and fittings.

J. Flood piping system with nitrogen when brazing.

K. Insulate piping; refer to Section 230719 .

L. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.

M. Fully charge completed system with refrigerant after testing.

3.3 FIELD QUALITY CONTROL

A. Test refrigeration system in accordance with ASME B31.5.

3.4 SCHEDULES

A. Hanger Spacing for Copper Tubing.
   1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.

3.5 ADJUSTING

A. Adjust set-point temperature of the conditioned air controllers to the system design temperature.

B. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

3.6 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter-dryer after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION

SECTION 23 31 00

HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Metal ducts.

1.2 DEFINITIONS

A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C168. In this Section, these values are the result of the formula Btu x in./h x sq. ft. x deg F or W/m x K at the temperature differences specified. Values are expressed as Btu or W.
   1. Example: Apparent Thermal Conductivity (k-Value): 0.25 or 0.037.

B. Pressure - Velocity Classification for Ductwork: As defined by SMACNA Duct Construction Standards - Metal and Flexible (latest edition), and applicable codes. Pressure classification for this specification:
   1. Low Pressure: Maximum 2500 FPM velocity; maximum 2.0 inches WG positive or -2.0 inches WG negative static pressure class.
   2. Medium Pressure: Maximum 4000 FPM velocity; maximum 4 inches WG positive or -3.0 inches WG or greater negative static pressure class.
   3. High Pressure: Velocity over 4000 FPM, pressure over 4 inches WG.

C. Gauge:
   1. Steel Sheet: U.S. Standard gauge.
   2. Aluminum Sheet: Brown & Sharpe schedule.
   3. Steel Wire: Washburn & Moen gauge.

D. Concealed Insulated Surfaces: Ductwork and equipment located in walls, partitions, floors, chases, shafts, and above ceilings.

E. Exposed Insulated Surfaces: Ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

1.3 REFERENCE STANDARDS

A. 29 CFR 1910.146 - Permit-Required Confined Spaces.

B. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals.

C. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

F. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

G. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

1.4 PERFORMANCE REQUIREMENTS

A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Design Professional. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

B. Size round ducts in lieu of rectangular ducts indicated in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.5 SUBMITTALS

A. Product Data: Provide data for all duct materials, duct liner, and duct connections.

B. Manufacturer's Installation Instructions: Indicate special procedures for glass fiber ducts.

C. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.

B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of documented experience.

C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members, and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

D. Comply with ASHRAE and SMACNA Design Handbooks.

1.7 FIELD CONDITIONS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures within acceptable range during and after installation of duct sealants.

1.8 DELIVERY, STORAGE AND HANDLING

A. Ductwork shall not be stored directly on the ground. Watermarked ductwork will not be accepted for installation.

B. Lined ductwork shall have all open ends sealed during delivery and storage periods.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Provide UL Class 1 ductwork, fittings, hangers, supports, and appurtenances in accordance with NFPA 90A and SMACNA (DCS) guidelines unless stated otherwise.

B. Acoustical Treatment: Provide sound-absorbing liners and sectional silencers for metal-based ducts in compliance with Section 23 33 19.

C. Duct Shape and Material in accordance with Allowed Static Pressure Range:
1. Round: Plus or minus 2 in-wc of galvanized steel.
2. Rectangular: Plus or minus 1/2 in-wc of galvanized steel.
3. Flat Oval: Plus 2 in-wc of galvanized steel.

D. Duct Sealing and Leakage in accordance with Static Pressure Class:
1. Duct Pressure Class and Material for Common Mechanical Ventilation Applications:
a. Low Pressure Supply: 1 inch w.g. pressure class, galvanized steel.
b. Return and Relief Air: 1 in-wc pressure class, galvanized steel.

E. Duct Fabrication Requirements:
1. Duct and Fitting Fabrication and Support: SMACNA (DCS) including specifics for continuously welded round and oval duct fittings.
2. No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
3. Use reinforced and sealed sheet-metal materials at recommended gauges for indicated operating pressures or pressure class.
4. Construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide airfoil turning vanes of perforated metal with glass fiber insulation.
5. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.

6. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
7. Provide turning vanes of perforated metal with glass fiber insulation when an acoustical lining is required.
8. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.2 MATERIALS

A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, FS Type B, with G90/Z275 coating.
   1. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
   1. Type: Water based, non-fibrated, heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
   2. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.
   3. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   4. Duct Sealing Rolled Sealant:
      a. Pressure sensitive, 40-year cycle, duct joint and general purpose rolled sealant. rated for use with sheet metal, duct board, flex board, PVC coated duct, and duct wrap vapor barriers.
      b. 100 percent solid elastomeric modified butyl with aluminum foil backing.
      c. Thickness: 17 Mils.
   5. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
   6. Flange and Joint Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

C. 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.

2.3 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. Hanger Materials: Galvanized sheet steel, threaded steel rod or steel cable with adjustable and removable locking mechanism.
   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap, Rod and Cable Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and steel rod diameters. Comply with SMACNA and manufacturer's recomendations for cable and locking mechanism sizes.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Cable Hanger System:
   1. Basis of Design: Gripple and Ductmate Clincher
   2. Products shall carry a 5:1 safety factor.
   3. SMACNA compliance - Tested and verified to be an acceptable hanger per the SMACNA, HVAC Duct Construction Standards.
   4. UL Listing - UL 1598 luminaire fitting sizes 1 - 5, UL 2289 Conduit and Cable Hardware sizes 2, 3 and 4.
   5. Housing: Type ZA2 Zinc.
   6. Wedge: Sintered steel hardened to min. 56 Rockwell C.
   7. Spring: 302 Stainless Steel.
   8. End Cap: UV stabilised homopolymer propylene.
   9. Wire Rope: Grade galvanized high tensile steel wire rope to EN12385.
   10. Toggle Plate and End Stop: Zinc plated steel.
   11. Stud Eyelet and Barrel End: Zinc plated steel.

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. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
   3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

F. Flexible Duct Elbow Supports:
   1. Universal-mount, 1-piece, fully adjustable, radius-forming brace to support 4-inch through 16-inch diameter flexible air ducts.
   2. Classified: UL 2043.
   3. Material: 100 percent recycled copolymer polypropylene.
   4. Support Frame Radius: 8 inches.
   5. Compliance for Flexible Duct Radius:
      a. SMACNA HVAC Duct Construction Standards.
      b. ASHRAE Advanced Energy Design Guides.
      c. ADC Flexible Duct Performance and Installation Standards.
   6. Basis of Design: FlexRight (Durable Elbow Support)

2.4 DUCTWORK FABRICATION

A. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation. Radius T's, bends and elbows less than 1-1/2 times width of duct on centerline are not allowed.

B. Low Pressure Ductwork: Construct all ductwork using galvanized steel except as indicated.
   1. Seams and Joints: Longitudinal seams shall be grooved seams, button punch snap lock or Pittsburgh lock. Transverse joints shall be drive slip. Joints 36-inch size and larger shall be manufactured duct joining system with downset corners, no-bolt design, or SMACNA T-25 formed on flanges with corner and cleat. Contractor option on smaller sizes.

C. Branch ducts to air devices shall be bell-mouth, conical or 45 degrees to round boot type fitting as a basis. Straight tap-ins, splitter dampers, and air extractors shall not be used.

D. Duct connections to fans/air-handling units shall be designed for proper entering and leaving conditions at the fan to avoid any adverse system effect fan losses.

2.5 MANUFACTURED DUCTWORK, FITTINGS AND CONNECTORS

A. Manufacturers:
   1. Ductmate Industries, Inc.:
   2. Eastern Sheet Metal.
   3. KB Duct
   4. LaPine Metal Products
   5. Lewis and Lambert
   6. Linx Industries
   7. Metal-Fab, Inc.: www.mtlfab.com.
   8. MKT Metal Manufacturing: www.mktduct.com/#sle.
   9. Nexus Inc.
   10. Norlock
   11. SEMCO Incorporated: www.semcoinc.com.
   12. S.E.T. Duct Manufacturing
   13. Sheet Metal Connectors.
   14. United McGill Corp.: www.unitedmcgill.com.
   15. Ward Industries, Inc.

B. Material Requirements:
   1. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.

C. Rectangular Metal Duct:
   1. Rectangular Double Wall Insulated: Rectangular longitudinal seam duct with galvanized steel outer wall.

D. Round Metal Ducts:

1. Round Single Wall Duct: Round lock seam duct with galvanized steel outer wall.

E. Round Spiral Duct:
1. Round spiral lock seam duct with galvanized steel outer wall.

F. Connectors, Fittings, Sealants, and Miscellaneous:
1. Fittings: Manufacture with solid inner wall of perforated galvanized steel.
2. Transverse Duct Connection System: SMACNA "E" rated rigid class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips in accordance with SMACNA (DCS).
3. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
   a. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
   b. VOC Content: Not more than 250 g/L, excluding water.
   c. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
   d. For Use with Flexible Ducts: UL labeled.
4. Gasket Tape:
   a. Provide butyl rubber gasket tape for a flexible seal between transfer duct connector (TDC), transverse duct flange (TDF), applied flange connections, and angle ring connections.

2.6 DUCT LINER

A. Refer to Section 23 0713 - Duct Insulation.

PART 3 EXECUTION

3.1 PRE-INSTALLATION

A. Field measure to determine exact conditions.

B. Provide duct opening closure film on all ductwork until final connections are completed.

C. Verify location of air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to reflected ceiling plans, finish schedule, material finish specification, and shop drawings.

D. Openings required for ductwork through structural elements in new construction shall be coordinated with the General Contractor. Shop drawings locating such openings shall be prepared in ample time to meet the construction schedule.

E. Coordinate and install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install ducts with a clearance of 2 inches, plus allowance for insulation thickness.

F. Coordination Process:
1. Provide coordination in determining adequate clearance and space requirements for mechanical equipment and electrical equipment and other items/equipment in

the project. The Design Professional reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Design Professional will only review conflicts and given an opinion but will not perform as a coordinator.

a. The coordination process shall utilize the actual equipment being provided. Refer to manufacturer's data for physical size, access and maintenance requirements. Provide all code required clearances.

2. Equipment layout and all system layouts shall confirm adequate clearances for installation, operation, maintenance, and code-required clearances from the structure or other equipment and systems. Provide offsets and elevation changes in piping, conduit and ductwork as required to complete the Layout and Coordination Process. Offsets and elevation change information shall be indicated in the coordination process documentation and must be submitted for review.
3. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Design Professional.
4. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings. Access to mechanical and electrical items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Design Professional at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.
5. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.
6. The Contractor and subcontractors responsible for items of work located in or above ceilings shall participate in the coordination process. Participation is mandatory. If the Contractor or subcontractor fails to participate in the coordination drawing process, the Owner reserves the right to do the following:
   a. Stop construction progress payments for work performed by the Contractor. Payments will be reinstated only after the Contractor or subcontractor resumes participation in the coordination drawing process.
   b. Require the relocation and resizing of components as necessary to ensure components will be installed as intended. In the event the Contractor did not participate in the coordination process, the Contractor will not be entitled to contract cost increases or time extensions due to Owner-initiated changes in the work.
   c. The Contractor shall be held responsible for unnecessary rework that is attributable to failure to participate in the coordination process.
7. Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Design Professional and the Owner for review on a monthly basis with changes “clouded” and brought to the attention of the Design Professional and the Owner.
8. When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Design Professional revisions necessary to the work of others not directly affected by the change order.

9. Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.

3.2 INSTALLATION

A. Install, support, and seal ducts in accordance with SMACNA (DCS).
   1. Hanging, Sealing and Supporting:
      a. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
      b. Support vertical ducts at a maximum interval of 16 feet and at each floor.
      c. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
      d. Install concrete inserts before placing concrete.
      e. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
         1) Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
      f. Seal ducts before external insulation is applied.

B. Install products following the manufacturer's instructions.

C. Comply with safety standards NFPA 90A and NFPA 90B.

D. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. Keep openings covered until ready for continuing duct run or final connections. Clean all unlined supply air ductwork during installation by swabbing with a non-toxic, non-flammable cleaning agent.

E. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

F. Provide volume dampers in all branch take-offs connecting to diffusers, registers and grilles, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
   1. Registers and diffusers with dampers shall be used only if devices are installed directly on the trunk duct.

G. Flexible Ducts: Connect to metal ducts with draw bands.
   1. Flexible ductwork shall be attached to metal collars or sleeves with draw bands. Duct adhesive shall be added to connections as required per duct system sealing class. Metal collars or sleeves 12 inches and larger shall contain draw band holding beads.

2. Low Pressure Ductwork: Peel back vapor barrier and fold back insulation; then secure to duct collar or sleeve with metal or nylon clamps or draw bands; then fold over insulation and vapor barrier and secure with two stretched wraps of approved cut tape.
3. Support flexible ductwork following manufacturer's recommendations and SMACNA HVAC Duct Construction Standards.
4. Final connections to air inlets and outlets may be made with flexible ductwork. Expanded length of flexible ductwork shall not exceed 36 inches. Path of flexible ductwork shall not exceed 45 degrees unless flexible duct elbow supports are provided.
5. Flexible Duct Elbow Supports:
    a. Install flexible duct elbow supports in accordance with manufacturer's instructions.
    b. Install flexible duct elbow supports over outer jacket of flexible ducts to form smooth, 90-degree bends to eliminate flexible duct kinks and airflow restrictions.
    c. Install flexible duct elbow supports at flexible duct 90-degree bends at following locations:
        1) Diffusers.
        2) Grilles.
        3) Registers.
        4) Duct take-offs and taps.
        5) Air devices with round inlets and outlets.
        6) HVAC equipment with round inlets and outlets.
        7) As indicated.

H. Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.

I. Provide openings in ductwork as indicated to accommodate thermometers and controllers. Provide pilot tube openings as indicated for testing of systems, complete with metal can with spring device or screw to insure against air leakage. For openings, insulate ductwork and install insulation material inside a metal ring.

J. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

K. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with a crimp in the direction of airflow.

L. Use double nuts and flat washer on threaded rod supports.

M. At exterior wall louvers, seal duct to louver frame.

N. Louver Fit-out:
1. Provide blank-out panels sealing available area of wall-mounted exterior-faced louver when connected ductwork is smaller than actual louver free area, and duct outlet is smaller than the louver frame.

2. Use the same duct material painted black on the exterior side, then seal louver frame and duct.

O. Penetrations:
1. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.
2. Provide sleeves at all duct penetrations through walls, floors and roofs. Openings through sound-rated partitions shall have annular space stuffed with fiberglass insulation for full thickness of wall.
3. Provide closure flanges around exposed ductwork at wall and ceiling penetrations, 1-1/4 inches wide minimum.

P. Install round and flat-oval ducts in lengths not less than 12 feet, unless interrupted by fittings.

Q. 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.

R. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

S. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

T. Prevent passage of unfiltered air around filters with felt, rubber, neoprene gaskets, or other approved safing material.

END OF SECTION

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air turning devices.

B. Duct access doors.

C. Duct test holes.

D. Volume control dampers.

E. Miscellaneous Products:
1. Internal strut end plugs.
2. Duct opening closure film.

F. Duct accessory hardware.

G. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

I. UL 555 - Standard for Fire Dampers.

J. UL 555S - Standard for Smoke Dampers.

1.2 SUBMITTALS

A. Product Data: Provide for shop-fabricated assemblies including volume control dampers, duct access doors, duct test holes, and hardware used. Include electrical characteristics and connection requirements.

B. Shop Drawings: Indicate for shop and field fabricated assemblies including volume control dampers and duct access doors.
1. Special fittings.
2. Motorized-control damper installations.
3. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer's Installation Instructions: Provide instructions for fire dampers, combination fire and smoke dampers, and smoke dampers.

D. Project Record Drawings: Record actual locations of access doors and test holes.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Fusible Links: One of each type and size.

F. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. Access Doors, Devices and Accessories:
1. Acudor Products Inc: www.acudor.com.
2. Carlisle HVAC Products: www.carlislehvac.com/sle.
3. Ductmate Industries, Inc.
4. Elgen Manufacturing: www.elgenmfg.com.
5. Flexmaster U.S.A., Inc.
6. Greenheck: www.greenheck.com
7. Krueger: www.krueger-hvac.com.
8. Lloyd Industries, Inc.: www.firedamper.com.
9. Nailor Industries Inc: www.nailor.com.
10. PCI Industries, Inc; Pottorff Brand [<>]: www.portorff.com.
11. Ruskin Company: www.ruskin.com.
12. SEMCO Incorporated: www.semcohvac.com.
13. Titus: www.titus-hvac.com.
14. United Enertech
15. Ventfabrics, Inc.
16. Vent Products Company, Inc.
17. Young Regulator Co
18. Ward Industries, Inc: www.wardind.com.

B. Dampers:
1. Air Balance, Inc.
2. Greenheck: www.greenheck.com
3. Louvers & Dampers, Inc: www.louvers-dampers.com.
4. Lloyd Industries, Inc.[<>]: www.firedamper.com.
5. Nailor Industries Inc[<>]: www.nailor.com.
6. NCA Manufacturing, Inc.: www.ncamfg.com
7. Pottorff/PCI Industries, Inc; Pottorff Brand : www.portorff.com.
8. Rossi: www.rossihardware.com
9. Ruskin Company: www.ruskin.com.
10. Tamco
11. United Enertech: www.unitedenertech.com/#sle.
12. Vent Products Company, Inc.
13. Ward Industries, Inc: www.wardind.com.

C. See paragraphs below for additional manufacturers.

2.2 SHEET METAL MATERIALS

A. 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.

B. Stainless Steel: ASTM A 480/A 480M.

C. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 AIR TURNING DEVICES

A. Multi-blade device with blades aligned in short dimension; steel construction; with individually and mounting straps.

2.4 DUCT ACCESS DOORS

A. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ducts, install minimum 1-inch thick insulation with sheet metal cover.
   1. Less Than 12 inches Square: Secure with sash locks.
   2. Up to 18 inches Square: Provide two hinges and two sash locks.
   3. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.
   4. Larger Sizes: Provide an additional hinge.
   5. Access doors shall be provided with sash locks only when clearance space does not allow a door swing.

B. Access doors with sheet metal screw fasteners are not acceptable.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with foam insulation fill and 1-inch thickness.
   1. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.
   1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

2.5 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.6 VOLUME CONTROL/BALANCING DAMPERS

A. Fabricate in accordance with SMACNA (DCS) and as indicated.

B. Single Blade Dampers:
1. Fabricate for duct sizes up to 6 by 30 inch.
2. Blade: 24 gauge, 0.0239 inch, minimum.

C. Multi-Blade Damper: Fabricate consisting of opposed blades with maximum blade sizes 8 by 72 inches. Assemble center- and edge-crimped blades in prime-coated or galvanized-channel frame with suitable hardware.
1. Blade: 18 gauge, 0.0478 inch, minimum.

D. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

E. Quadrants:
1. Provide positive-locking, indicating quadrant regulators on single and multi-blade dampers.
2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
3. Where rod lengths exceed 30 inches provide regulator at both ends.

2.7 MISCELLANEOUS PRODUCTS

A. Internal Strut End Plugs: Combination end-mounting and sealing plugs for metal conduit used as internal reinforcement struts for metal ducts; plug crimped inside conduit with outside gasketed washer seal.

B. Duct Opening Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during construction.
1. Thickness: 2 mils.
2. High tack water based adhesive.
3. UV stable light blue color.
4. Elongation Before Break: 325 percent, minimum.

C. Jackshaft: 1-inch-diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). See Section 23 31 00 for duct construction and pressure class.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Provide duct test holes where indicated and required for testing and balancing purposes.

D. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum two duct widths from duct take-off.

E. Provide volume control (balancing) dampers on duct take-off to all air inlets and outlets, diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

F. Provide volume control (balancing) dampers in all duct systems where indicated and required to perform complete system test and balance. Coordinate all volume damper locations with the test and balance contractor.

G. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

H. Provide turning vanes in all mitered duct turns.

I. Provide filter gage for each filter bank.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual-volume dampers is specified in Section 23 0593 - Testing, Adjusting, and Balancing.

3.3 DEMONSTRATION

A. Demonstrate the following to the owner's representative and maintenance personnel:
1. Access to all volume damper position controls.

END OF SECTION

SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Retrofit terminal units.

B. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.

C. AHRI 880 (I-P) - Performance Rating of Air Terminals.

D. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

E. NFPA 70 - National Electrical Code.

F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

G. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.2 SUBMITTALS

A. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate airflow, static pressure, and NC designation. Include electrical characteristics and connection requirements.

B. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
   1. Include schedules listing discharge and radiated sound power level for each of the second through sixth-octave bands at inlet static pressures of 1 to 4 in-wc.

C. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.

D. Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.

E. Project Record Documents: Record actual locations of units and locations of access doors required for access of valving.

F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.

G. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.4 WARRANTY

A. See Section 01 78 00 - Closeout Submittals for additional warranty requirements.

B. Provide one year manufacturer warranty for fan powered air terminal units.

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
   1. Coordinate maintenace clearance requirements of all terminal unit controls components prior to ordering and submitting units for review.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 MANUFACTURERS

A. Krueger.; www.krueger-hvac.com

B. Metalaire Inc.; Metal Industries Inc.

C. Nailor Industries Inc.: www.nailor.com.

D. Price Industries.; www.priceindustries.com/

E. Titus; www.titus-hvac.com

2.3 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, room number served, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

2.4 RETROFIT TERMINAL UNITS

A. Basis of Design: Titus: www.titus-hvac.com
   1. Slide-in Retrofit Terminal Units: DQCV (direct digital controls).

B. General:
   1. Factory-assembled, air volume control units, rated in accordance with AHRI 880 (I-P).
   2. Slide-in/slip-in retrofit terminal units are designed for installation in rectangular ductwork to easily convert a constant volume system into a variable air volume (VAV) system. To install the retrofit terminal unit, a rectangular hole is cut in the existing ductwork and the unit is slid in. The unit can then be fastened to the duct with a heavy gauge mounting plate and steel mounting angles.
   3. The terminal shall be documented with catalog and test data for sound levels and differential static pressure requirements.
   4. Clearly label each unit indicating maximum/minimum cfm, tag/mark number, model number, and manufacturer's order number.

C. Construction:
   1. Casing: Minimum 22 gauge, 0.0299 inch galvanized steel, acoustically and thermally lined with minimum 1/2 inch, dual-density insulation, meeting the requirements of NFPA 90A, UL 181, and ASTM C1071.
   2. Controls Enclosure: 22 gauge, 0.0299 inch zinc-coated steel.
   3. Air volume control assembly to consist of a galvanized steel damper, opposed blade type with 14-gauge airfoil blades of steel or aluminum.
   4. Acceptable air balancing assemblies include integral damper.

D. Electrical Requirements:
   1. Single-point power connection.
   2. Equipment wiring to comply with requirements of NFPA 70.

E. Controls:
   1. DDC (Direct-Digital Controls):
   2. Airflow Sensor: Differential pressure airflow device measuring total, static, and wake pressures.
      a. Plastic parts are fire-resistant, complying with UL 94.
      b. Provides accuracy within 5 percent with a 90 degree sheet metal elbow directly at the inlet of the assembly.
      c. Control tubing is protected by grommets at the wall of the air flow sensor's housing.
      d. Provide sensor with a pressure transducer to interface with a DDC system.
      e. Provide velocity pressure sensor with a removable access section for maintenance.
   3. Control Sequence: See Section 23 09 93.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that conditions are suitable for installation.

B. Verify that field measurements are as indicated on drawings.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions. Provide a minimum of 18" clearance to all servicable control components.

B. Provide all code required service clearances.

C. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.

D. Coordinate locations of control components, electrical clearances, and access doors or panels with installation space available. Adjust indicated location of terminal unit if necessary to acheive required service clearances.

E. Locate units above easily removable ceiling components.

F. Support units individually from structure.

G. Embed anchors in concrete in accordance with ASTM E488/E488M.

H. Do not support units from adjacent ductwork.

I. Connect to ductwork in accordance with Section 23 31 00.

J. Provide minimum of 5 ft of 1 inch thick lined ductwork downstream of units.

K. Verify that electric power is available and of the correct characteristics.

L. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.3 CONNECTIONS

A. Provide straight run of inlet supply ductwork as required by manufacturer.

B. Connect ductwork according to 23 3100 - HVAC Ducts and Casings. Prvide inlet and outlet duct connections as recommended by air terminal unit manufacturer to achieve proper performance.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

3.5 ADJUSTING

A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to zero percent full flow.

3.6 FIELD QUALITY CONTROL

A. Provide manufacturer's field representative to inspect and instruct field-assembled components and equipment installation, including connections. Report results in writing.
   1. Complete installation and startup checks according to manufacturer's written instructions and do the following:
      a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
      b. Verify that controls and control enclosure are accessible.
      c. Verify that control connections are complete.
      d. Verify that nameplate and identification tag are visible.
      e. Verify that controls respond to inputs as specified.
   2. Operational Test:
      a. Test and adjust controls and safeties.
      b. Replace damaged and malfunctioning controls and other equipment.
      c. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 23 37 00

AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Ceiling gypsum board access panels.

B. Roof hoods.

1.2 REFERENCE STANDARDS

A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating.

B. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Air Inlets.

C. SMACNA (ASMM) - Architectural Sheet Metal Manual.

D. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

1.3 SUBMITTALS

A. Specification Compliance Review.

B. Product Data: Provide data for equipment required for this project. Review roof hoods as to size, finish, and type of mounting prior to submission.

C. Product Data: For each model indicated, include the following:
   1. Data Sheet: For each type of roof hood and access panel, and accessory furnished; indicate construction, finish, and mounting details.
   2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of roof hood.
   3. Assembly Drawing: For each type of roof hood and access panel; indicate materials and methods of assembly of components.

D. Project Record Documents: Record actual locations of air outlets and inlets.

1.4 QUALITY ASSURANCE

A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.

B. Test and rate louver performance in accordance with AMCA 500-L.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of intake and relief ventilators and are based on the specific equipment indicated.
   1. Do not modify intended aesthetic effects, as judged soley by Design Professional, except with Design Professional's approval. If modifications are proposed, submit comprehensive explanatory data to Design Professional for review.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 MANUFACTURED UNITS

A. General: Sizes, types and capacities shall be as indicated.

B. Ceiling and wall frame types and dimensions shall be verified from architectural drawings.

C. Verify ceiling frame and panel style and dimension with reflected ceiling plan, room finish schedule and material type.

D. If final diffusers or registers have a higher sound level than those specified or if dimensions are not compatible with finished walls, ceilings, floors or architectural air cabinets (millwork), installed diffusers and registers shall be replaced at the Contractor's expense.

E. Outlets and inlets shall be factory baked enamel finished with color selected by Design Professional unless indicated.

2.3 WALL AND CEILING GYPSUM BOARD ACCESS PANELS

A. Gypsum Board Access Panels: Provide rectangular access panel with recessed and gasketed aluminum perimeter frame that acts as finishing edge and having concealed mechanical touch-latch with safety cable.
   1. Panel Frame Size: 24 by 24 inch set within 1/2 inch thick gypsum board.
   2. Panel Frame: 1 inch margin with concealed countersunk screw mounting.
   3. Manufacturers:
      a. BAUCO Access Panel Solutions Inc; BAUCO Plus II Access Panels: www.accesspanelsolutions.com/#sle.

2.4 ROOF HOODS

A. Manufacturers:
   1. Greenheck: www.greenheck.com..
   2. Loren Cook Company: lorencook.com..
   3. Twin City Fan & Blower: www.tcf.com..
   4. Other if approved in writing by the Engineer.

B. Fabricate air inlet or exhaust hoods in accordance with SMACNA (DCS).

C. Fabricate of galvanized steel, minimum 16 gauge, 0.0598 inch base and 20 gauge, 0.0359 inch hood, or aluminum, minimum 16 gauge, 0.0598 inch base and 18 gauge, 0.0598 inch hood; suitably reinforced; with removable hood; birdscreen with 1/2 inch square mesh for exhaust and 3/4 inch for intake, and factory prime coat finish.

D. Fabricate louver penthouses with mitered corners and reinforce with structural angles.

E. Mount unit on minimum 20 inch high curb base with insulation between duct and curb.

F. Make hood outlet area minimum of twice throat area.

G. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
   1. Configuration: Built-in cant and mounting flange.
   2. Overall Height: 20.

H. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch.

I. Galvanized-Steel Sheet Finish:
   1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.

C. Install intake and relief ventilators level, plumb, and at indicated alignment with adjacent work. Install roof curb level. Install with openings no less than 36 inches above finished roof surface.

D. Secure intake and relief ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible.

E. Install intake and relief ventilators with clearances for service and maintenance.

F. Label intake and relief ventilators according to requirements specified.

G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, as directed and as required to prevent drafts before starting air balancing.

B. Adjust air patterns per manufactures recommendations based on installed conditions.

3.4 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION

SECTION 23 74 13

PACKAGED OUTDOOR ROOFTOP UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Packaged outdoor rooftop units, variable air volume.

B. Roof mounting plenum curb.

C. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

D. AHRI 270 (SI/I-P) - Sound Performance Rating of Outdoor Unitary Equipment.

E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Pre-purchased Equipment: The major equipment described in this specification has been prepurchased by the Owner through their Contractor. This document shall serve to document the general performance criteria of the purchased equipment and specify installation requirements and accessories.

B. Coordinate the work with other trades for installation of roof mounted packaged rooftop units on roof curbs.

C. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.3 SUBMITTALS

A. Product Data: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.

B. Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.

C. Manufacturer's Instructions: Indicate assembly, support details, connection requirements, and include start-up instructions.

D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

E. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 60 00 - Product Requirements for additional provisions.
2. Extra Filters: One set for each unit.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

C. Where the National Electrical Code or applicable codes require controllers to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off site until roof mounting curbs are in place, ready for immediate installation of units.

1.6 WARRANTY

A. Manufacturer's standard form in which manufacturer agrees to repair or replace components of equipment that fail in materials or workmanship within specified warranty period. Warranty period for:
1. Compressors and Refrigerant: Five (5) years.
2. Heat Exchangers: Fifteen (15) years.
3. Whole Unit Parts - Three (3) years.

B. Provide a five year warranty to include coverage for refrigeration compressors.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 MANUFACTURERS

A. Daikin Applied: www.daikinapplied.com.

B. Innovent: www.innoventair.com.

C. Trane, a brand of Ingersoll Rand: www.trane.com.

D. Other, if approved in writing during the bid period by the Engineer and Owner.

2.3 MANUFACTURED UNITS

A. General: Roof mounted units having a heat exchanger and gas burner and electric refrigeration.

B. Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, heat exchanger and burner, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan.

C. Refrigerant: R-454B or R-32, listed to UL Standard 60335-2-40, with a factory-installed A2L refrigerant leak detection system.

D. Electrical Characteristics:
1. 208 VAC, three phase, 60 Hz.
2. 65kA Short Circuit Current Rating (SCCR)

E. Disconnect Switch: Factory mount disconnect switch in control panel.

F. Where the National Electrical Code or applicable codes require controllers to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment.

2.4 FABRICATION

A. Cabinet: Galvanized steel with a weather resistant baked enamel finish meeting 500+ hour ASTM B117 salt spray test, including hinged access panels with integrated quarter turn latches.. Structural members shall be minimum 18 gauge, 0.0478 inch, with access panels of minimum 20 gauge, 0.0359 inch.

B. Condensate Drain Pan: Stainless steel, double sloped.

C. Hoods: Outside air/economizer and/or relief, galvanized steel with a weather resistant baked enamel finish meeting 500+ hour ASTM B117 salt spray test.

D. Louvers: Manufacturer's standard louvers for outside air/economizer and/or relief, galvanized steel with a weather resistant baked enamel finish meeting 500+ hour ASTM B117 salt spray test.

E. Insulation: R-13 minimum.

F. Heat Exchangers: Stainless steel, of welded construction.

2.5 SUPPLY FAN:

A. Direct drive type, resiliently mounted.

B. Airfoil blades.

C. ECM motor or manufacturer provided variable frequency controller(s).

D. Multiple fans in an array are preferred.

2.6 AIR FILTERS:

A. Pleated Media Filters:
1. Media: 100 percent synthetic fibers, continuously laminated to a grid with water repellent adhesive, and capable of operating up to a maximum of 625 fpm (3.17 m/s) without loss of efficiency and holding capacity.
2. Frame: Steel wire grid.

B. Prefilters and Final Filters:
1. Prefilter Media: 2 inch, pleated, 8 MERV, disposable .
2. Final Filter Media: 4 inch, pleasted, 13 MERV, disposable.
3. Filter Rack: Side-access rack designed to hold the metal headers.

2.7 HEAT EXCHANGERS AND BURNERS

A. Heat Exchangers: Stainless steel, drum and tube design, with gasketed cleanout plate.

B. Modulating Gas Burners: Forced draft type burners with adjustable combustion air supply, pressure regulator, gas valves, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot.

C. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after airflow proven and slight delay, allow gas valve to open.

D. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.

E. Supply Fan Control: Temperature sensor sensing bonnet temperatures and independent of burner controls, with provisions for continuous fan operation.

2.8 EVAPORATOR COIL

A. Provide copper tube aluminum fin coil assembly with stainless steel drain pan and connection.

B. Provide capillary tubes or thermostatic expansion valves for units of 6 Tons of refrigeration capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 Tons of refrigeration cooling capacity and larger.

2.9 HOT GAS REHEAT COIL

A. Provide an aluminum tube micro-channel coil assembly for dehumificiation reheat operation.

2.10 COMPRESSOR

A. Provide direct-drive hermetic digital scroll compressors, 3600 rpm maximum, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gage ports, and filter drier.

B. At least one compressor stage must be an inverter-lead circuit type variable speed/capacity compressor with turndown to 10%. Other stages may be fixed speed compressors. Capacity control is accomplished by staging fixed speed compressors and modulating the capacity of the variable speed compressor.

2.11 CONDENSER COIL

A. Provide copper tube aluminum fin coil assembly with subcooling rows and coil guard.

B. Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Provide high efficiency fan motors.

C. Condenser fans shall modulate their speed to provide low ambient control down to 25 deg F.

D. Provide louvered condenser coil guards to protect from hail, wind, and other damage.

2.12 MIXED AIR CASING

A. Dampers: Provide outside, return, and relief dampers with damper operator and control package to automatically vary outside air quantity. Motorized outside air damper to fail to closed position. Relief air shall be exhausted by power exhaust fans. .

B. Gaskets: Provide tight fitting outdoor dampers with edge gaskets maximum leakage 5 percent at 2 inches pressure differential.

C. Damper Operator: 24 volt with gear train sealed in oil.

2.13 ECONOMIZER

A. Provide a 0 to 100 percent reference enthalpy economizer with powered exhaust.
   1. The economizer will compare the measured enthalpy of the outside air to a reference enthalpy setpoint to determine if it is cool enough and dry enough to allow the unit to go into economizing mode. Economizers that compare the measured enthalpy of the outside air to the measured enthalpy of the return air shall not be acceptable.
   2. The rooftop unit shall have a factory provided outdoor airflow monitoring station (Ebtron or equal) for accurately measuring outdoor airflow to precisely control ventilation.

2.14 CONDENSER COIL COTTONWOOD HAIL GUARD/INTAKE FILTER SCREENING (BY MECHANICAL CONTRACTOR):

A. Engineered HVAC Mesh

B. Non-porous, UV resistant, vinyl coated polyester media w/non-stick surface.
   1. Flame resistant (self-extinguishing)
   2. Low debris adhesion
   3. Mold and mildew resistant.

C. 1.125” heavy duty fiber reinforced outer binding.
   1. Quick release nylon twist-lock fasteners.

D. Low air resistance and static pressure impact

E. 10 year Warranty

F. Basis of design: Air Solution Company, Heavy Duty Commercial Grade

2.15 POWER AND CONTROLS

A. Equipment and controls shall to interface and integrate to BMCS systems and sequences via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.

B. All remote sensors required by the factory-installed controller, including outside and supply air temperature, outside and supply air humidity sensors, and duct and building pressure sensors shall be furnished by the rooftop unit manufacturer. Unless otherwise noted, these sensors shall have a wired connection to the associated rooftop unit.
   1. The rooftop unit shall be capable of taking CO2 readings from the BMCS in lieu of directly wired CO2 sensors.

C. Motor Control Panels: UL listed.

D. Include necessary motor starters, fuses, transformers and overload protection according to NFPA 70.

E. Provide single-point field connection to power supply.

F. Provide non fused main disconnect integral to control panel.

G. Provide 120 volt field wired GFCI convenience receptacle/outlet.

H. Install wiring in accordance with NFPA 70.

I. Wiring: Enclosed in flexible, liquid tight steel conduit.

2.16 ROOF MOUNTING PLENUM CURBS

A. Manufacturers:
   1. Insulated Curbs: Thybar (www.thybar.com) or approved in writing equal.

B. Insulated Plenum Curb: G-90 Galvanized steel, reinforced sides, fully welded corners, base flange attachments for securing to building structure, factory installed wood nailer, gasketing, factory insulated at the exterior panels with minimum 3 inch thick, 3 pcf density rigid fiberglass insulation (R-12), with two plenums with floors and roofs to connect to supply and return air ductwork.
   1. Basis of Design: Thybar TC-3.
   2. Plenums: Separate supply air and return air plenums shall be separated by a sheetmetal divider insulated with 1.5 inches of 3 pcf density rigid fiberglass insulation (R-6). The downflow packaged rooftop unit supply and return duct connections and existing supply and return ducts through the roof shall be connected to their respective plenums.
   3. See the mechanical drawings for approximate curb dimensions and additional information. The exact curb dimentions shall be coordinated between the curb manufacturer, installing contractor, and rooftop unit supplier/manufacturer.

C. Vibration Isolation Rail Assembly:
   1. General Description: A vibration isolation rail assemby shall be installed between the plenum roof curb (by others) and the supported equipment.
   2. Basis of Design: Vibro-Acoustics Model ARTR (virs.vibro-acoustics.com).
      a. Other manufacturers are acceptable if approved in writing by the Engineer during the project bid period.
   3. Isolators: Adjustable 2 inch (50 mm) static deflection springs, with all-directional restraints.
   4. Rail: Minimum 4 inch (102 mm) high gauge G90 galvanized steel top channel, full perimeter.
   5. Weather Seal: Full perimeter reinforced EPDM.
      a. Provide a top arrangement with a counter-flashing for rooftop units that do not have a perimeter base with an overhang.

PART 3 EXECUTION

3.1 EXAMINATION (BY MECHANICAL CONTRACTOR)

A. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.

B. Verify that proper power supply is available.

3.2 CONNECTIONS (BY MECHANICAL AND ELECTRICAL CONTRACTORS)

A. Coordinate installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to machine to allow service and maintenance.

1. Gas 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.

D. Coordinate duct installation requirements with schematics on Drawings and with requirements specified for duct systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

E. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
1. Install ducts to termination in roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to rooftop unit with flexible duct connectors.
4. Terminate return-air duct through roof structure and insulate space between roof and bottom of unit with 2-inch thick, acoustic duct liner.
5. Provide flexible connection between ductwork and rooftop unit.

F. Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

G. Ground equipment according to Division 26 Section "Grounding and Bonding."

H. 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 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 quality-control tests and inspections and prepare test reports:
1. After installing rooftop air conditioners and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
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.

C. Remove malfunctioning units, replace with new units, and retest as specified above.

3.4 ADJUSTING (BY MECHANICAL AND ELECTRICAL CONTRACTORS)

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.5 DEMONSTRATION

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

3.6 INSTALLATION (BY MECHANICAL CONTRACTORS)

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 90A.

C. Provide filter gage on each filter bank. Refer to Section 23 3300.

3.7 SYSTEM STARTUP

A. Prepare and start equipment. Adjust for proper operation.

B. Engage a factory-authorized service representative to perform startup service.

C. Complete installation and startup checks according to manufacturer's written instructions and do the following:
1. Clean outside coil and inspect for construction debris.
2. Connect and purge gas line.
3. Adjust vibration isolators.
4. Inspect operation of barometric dampers.
5. Lubricate bearings on fan.
6. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
7. Start unit according to manufacturer's written instructions.
    a. Start refrigeration system in summer only.
    b. Complete startup sheets and attach copy with Contractor's startup report.
8. Inspect and record performance of interlocks and protective devices; verify sequences.
9. Operate unit for an initial period as recommended or required by manufacturer.
10. Calibrate thermostats.
11. Adjust and inspect high-temperature limits.
12. Inspect outside-air dampers for proper stroke and interlock with return-air dampers.
13. Start refrigeration system and measure and record the following:
    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.

14. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
15. Simulate maximum cooling demand and inspect the following:
    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through outside coil or from outside coil to outside-air intake.
16. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:
    a. High-limit heat exchanger.
    b. Warm-up for morning cycle.
    c. Freezestat operation.
    d. Economizer to limited outside-air changeover.
    e. Alarms.
17. After startup and performance testing, change filters, vacuum cooling and outside coils, and lubricate bearings.

END OF SECTION

SECTION 23 81 26.13

SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air cooled condensing units.

B. Indoor air handling (fan and coil) units for ducted systems.

C. Controls.

1.2 REFERENCE STANDARDS

A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

B. AHRI 270 (SI/I-P) - Sound Performance Rating of Outdoor Unitary Equipment.

C. AHRI 520 - Performance Rating of Positive Displacement Condensing Units.

D. AHRI 610 (I-P) - Performance Rating of Central System Humidifiers for Residential Applications.

E. ASHRAE Std 15 - Safety Standard for Refrigeration Systems.

F. ASHRAE Std 23 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Compressor Units.

G. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.

H. ASHRAE Std 90.2 - High-Performance Energy Design of Residential Buildings.

I. ASHRAE Std 103 - Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers.

J. NEMA MG 00001 - Motors and Generators.

K. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

L. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical.

M. 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.

1.3 SUBMITTALS

A. Specification Compliance Review.

B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.

D. Design Data: Indicate refrigerant pipe sizing.

E. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.

F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

G. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Extra Filters: One for each unit.
3. Extra Pilot Thermocouples: One for each unit.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years of experience and approved by manufacturer.

1.5 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases.

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations.

1.6 WARRANTY

A. Provide the manufacturer's standard warranty.

PART 2 PRODUCTS

2.1 MANUFACTURERS - HEATING AND COOLING

A. AboveAir Technologies: www.aboveair.com

B. Innovent: www.innoventair.com

C. Trane: www.trane.com

D. Other if approved in writing by the Engineer during the project bid period.

2.2 SYSTEM DESIGN

A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
1. Heating: Electric resistance heating.
2. Cooling: Outdoor electric condensing unit with evaporator coil in central ducted indoor unit.
3. Provide refrigerant lines internal to units and between indoor and outdoor units according to the requirements of Section .
4. Provide trapped coil condensate piping between indoor unit evaporator drain plan and terminate where indicated on the mechanical plans.

B. Performance Requirements: See Drawings for Equipment Schedule.
1. Disconnect Switch: Factory mount disconnect switch on equipment under provisions of Section 26 05 83.

2.3 INDOOR AIR HANDLING UNITS FOR DUCTED SYSTEMS

A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
1. Air Flow Configuration: Horizontal.
2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
3. Control: Single zone, variable air volume.

B. Refrigerant: R-454B or R-32, listed to UL Standard 60335-2-40, with a factory-installed A2L refrigerant leak detection system, as required by the UL standard.

C. Supply Fan: Direct drive, backward inclined impeller.

D. Motor: Electrically Commutated Motor (ECM)
1. Synchronous rotation. Variable speed direct current brushless. Permanent magnet.
2. Permanently lubricated ball bearings.
3. Integrated controller/inverter operates the wound stator and senses rotor position to electronically commutate the stator. Soft start and soft speed change ramps.
4. Starting Torque: Exceeding one fourth of full load torque.
5. Breakdown Torque: Approximately 250 percent of full load torque.
6. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor.

E. Air Filters:
1. 4" MERV 13 pleated disposable air filter.

F. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
   1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
   2. Manufacturers: System manufacturer.

G. Electric Heat:
   1. Stainless steel contruction.
   2. SCR controlled.
   3. Reheat/heat operation.

H. Outside Air Control:
   1. Manufacturer provided remote mixing box with outside air and return air dampers modulated according to the manufacturer's space CO2-based demand controlled ventilation sequence of operation.
   2. Manufacturer furnished space CO2 sensor.

2.4 OUTDOOR UNITS

A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
   1. Comply with AHRI 210/240.
   2. Refrigerant: R-454B or R-32, listed to UL Standard 60335-2-40, with a factory-installed A2L refrigerant leak detection system, as required by the UL standard.
   3. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
   4. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23 and UL 207.
   5. Sound Rating: 69 dBA, when measured in accordance with AHRI 270 (SI/I-P).

B. Compressor: Scroll, modulating digital control 3600 rpm, AHRI 520 resiliently mounted integral with condenser, with low ambient control down to -20 deg F. Provide time delay control to prevent short cycling.

C. Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
   1. Condenser Fans: Direct-drive propeller type, variable speed.
   2. Condenser Fan Motor: Enclosed, 1-phase type, permanently lubricated.
   3. Cottonwood/Hail Guard Coil Filter Screening:
      a. Engineered HVAC Mesh
      b. Non-porous, UV resistant, vinyl coated polyester media w/non-stick surface.
         1) Flame resistant (self-extinguishing)
         2) Low debris adhesion
         3) Mold and mildew resistant.
      c. 1.125” heavy duty fiber reinforced outer binding.
         1) Quick release nylon twist-lock fasteners.
      d. Low air resistance and static pressure impact

e. Provide with Hail-Proof backing mesh w/aluminum mounting track.
f. 10 year Warranty
g. Basis of design: Air Solution Company, Heavy Duty Commercial Grade

D. Coil: Air-cooled, aluminum fins bonded to copper tubes.

E. Accessories: Filter drier, high-pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
1. Provide thermostatic expansion valves.

F. Operating Controls:
1. Control by room thermostat to maintain room temperature setting by single zone variable air volume control.
2. Equipment and controls shall to interface and integrate to BMCS systems and sequences via vendor protocols including, as a minimum, BACnet, LonTalk and Modbus.
3. Ventilation shall be controlled by the manufacturer's space CO2 based demand controlled ventilation algorithm and manufacturer provided CO2 sensor and outside air and return air control dampers.

G. Mounting: See mechanical drawings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.

B. Verify that proper power supply is available and in correct location.

C. Verify that proper fuel supply is available for connection.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.

B. Install in accordance with NFPA 90A.

C. Install refrigeration systems in accordance with ASHRAE Std 15.

D. Install units level and plumb.

E. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

F. Install roof-mounting compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

G. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

H. Provide trapped coil condensate piping between indoor unit evaporator drain plan and terminte over nearest floor drain.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangements of piping, fittings, and specialties.

B. Refrigerant Piping: As specified elsewhere in the mechanical drawings and specifications. Size per the split system manufacturer's recommendations.

C. Install piping adjacent to unit to allow service and maintenance.

D. Provide trapped coil condensate piping between indoor unit evaporator drain plan and terminate where indicated on the mechanical plans.

E. Duct Connections: As specified elsewhere in the mechanical drawings and specifications.

F. Ground equipment according to the electrical drawings and specifications.

G. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.4 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 and prepare test reports:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.

END OF SECTION

SECTION 23 82 00

CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electric wall heaters.

B. Electric duct heaters.

1.2 REFERENCE STANDARDS

A. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.

B. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality.

C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

1.3 SUBMITTALS

A. Specification Compliance Review.

B. Product Data: Provide typical catalog of information including arrangements.

C. Shop Drawings:
1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
2. Indicate air coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
3. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
4. Indicate mechanical and electrical service locations and requirements.

D. Certificates: Certify that coils are tested and rated in accordance with AHRI 410. Coil capacities, pressure drops, and selection procedures meet or exceed specified requirements.

E. Manufacturer's Instructions: Indicate installation instructions and recommendations.

F. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.

G. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

H. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Filters: One set of each type and size.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.5 WARRANTY

A. Provide the manufacturer's standard warranty.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Equipment Schedules with Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 ELECTRIC WALL HEATERS

A. Manufacturers:
1. Modine Manufacturing Company: www.modineHVAC.com.
2. Raywall: www.raywall.com.
3. Berko (A brand of Marley Engineered Products): www.marleymep.com.

B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for purpose indicated.

C. Heating Element Assembly:
1. Thermal safety cut-out within electric terminal box with automatically reset switch located near electric terminal box.
2. Horizontal Projection Units:
a. Nickel chromium resistance wire surrounded with magnesium oxide and sheathed in steel, spiral-finned tubes.

D. Housing:
1. Suitable for wall mounting.
2. Horizontal Projection Units:
a. Construction materials to consist of heavy gauge steel with galvanized, polyester powder coat, or high gloss baked enamel finish.
b. Provisions for access to internal components for maintenance, adjustments, and repair.

E. Air Inlets and Outlets:
1. Provide protective grilles with fan blade guard.

F. Fan: Factory balanced, direct drive, axial type with fan guard.

G. Motor: Totally enclosed, thermally protected, and provided with permanently lubricated bearings.

H. Controls:
1. Built-in line-voltage thermostat concealed behind the front grille panel.

I. Electrical Characteristics:
1. Factory installed double-pole single throw on/off switch.
2. See Section 26 05 83.

2.3 AIR COILS

A. Electric Coils:
1. Manufacturers:
a. Brasch Manufacturing Company: www.braschmfg.com/.
b. INDEECO: www.indeeco.com/.
2. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for purpose indicated.
3. Heater Coil Assembly:
a. Minimum 20 gauge, 0.0359 inch thick, galvanized or corrosion resistant steel cabinet.
b. Terminal control box with hinged access cover, heating elements, and controls.
c. Relay or Contactor Controlled Heating Section:
1) Open Coil: Nickel chromium heating element, stainless steel or nickel plated terminals supported in ceramic bracket bushings.
2) Over-Temperature Protection: Provide thermal cutouts for primary and secondary over-temperature protection.
d. Duct End Connections:
4. Heater Controls:
a. Interlocked airflow switch.
b. Control circuit step-down transformers.
c. 0-10 VDC SCR controller.
1) Note: The electric duct heater will be controlled by a VAV air terminal unit controller.
d. Dry contact for remote heater enable.
1) Note: The dry contact shall be interlocked with the refrigerant leak detector in the associated air handling unit to disable the heater if a leak is detected.
5. Electrical Characteristics:
a. Factory mounted electrical disconnect switch
b. See Section 26 05 83.

2.4 HYDRONIC RADIANT PANELS

A. Manufacturers:
1. Hydro-Air Components, Inc: www.rittling.com.
2. TWA Panel Systems, Inc.: www.twapanels.ca.

B. Ceiling Panels: Constructed of modular 5 inch wide aluminum extrusions with interlocking edges; manufactured and assembled to sizes and configurations indicated.
1. Pipe Coil: Incorporate extruded void into which continuous 1/2 inch copper pipe is rolled and thermally bonded. Provide return bends for two water connections to each panel.
2. Where indicated, incorporate extruded drapery track.
3. Cross brace entire assembly with structural members and insulate with 1 inch thick fiberglass insulation. Configure panels within T-bar ceiling module and run wall to wall.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are suitable for installation.

3.2 INSTALLATION

A. Install in accordance with manufacturer's recommendations.

B. Provide all code required service clearances.

C. Provide code required access clearances, 36" minimum, to all electrical components and panels.

D. Install equipment exposed to finished areas after walls and ceilings are finished and painted.

E. Do not damage equipment or finishes.

F. Baseboard Radiation:
1. Locate on outside walls and run cover continuously wall-to-wall unless otherwise indicated.
2. Center elements under window with elements of equal length centered under each window for multiple windows.
3. Install end caps where units butt against walls.

G. Finned Tube Radiation:
1. Locate on outside walls and run cover continuously wall-to-wall unless otherwise indicated.
2. Center elements under window with elements of equal length centered under each window for multiple windows.
3. Install wall angles and end caps where units butt against walls.
4. Align cabinet joints with window mullions.

5. Install wall angles where units butt against walls and align cabinet joints with window mullions.

H. Convectors:
1. Install where indicated.
2. Coordinate to ensure correct recess size for recessed convectors.

I. Unit Heaters:
1. Hang from building structure, with pipe hangers anchored to building, not from piping or electrical conduit.
2. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

J. Cabinet Unit Heaters:
1. Install as indicated.
2. Coordinate to ensure correct recess size for recessed units.

K. Fan-Coil Units:
1. Install as indicated.
2. Coordinate to ensure correct recess size for recessed units.

L. Unit Ventilators:
1. Locate as indicated, level and shim units, and anchor to structure.
2. Coordinate exact location of wall louvers.
3. Install shelving and auxiliary cabinetry.
4. Provide wall trim pieces for continuous wall-to-wall installation.

M. Units with Hydronic Coils:
1. Provide with shut-off valve on supply piping and tamper-proof, balancing valve with memory stop on return piping.
2. If not easily accessible, extend air vent to exterior surface of cabinet for ease of servicing.
3. Provide float operated automatic air vents with stop valve for cabinet unit heaters, fan coil units, and unit heaters.

N. Units with Cooling Coils: Connect drain pan to condensate drain.

O. Blower-Coil Units:
1. Verify all surfaces and openings at unit location can suitably accommodate unit(s).
2. Install in accordance with manufacturer's recommendations.
3. Provide manual shut-off valve on hydronic supply side of coil and balancing valve with memory stop on return side.
4. General piping installation requirements are specified in other Sections and drawings indicate general arrangement of piping, fittings, and specialties.
5. Connect steam, hydronic, steam condensate, condensate drain, and overflow drain piping to unit.

P. Air Coils:

1. Install in ducts and casings in accordance with SMACNA (DCS).
    a. Support coil sections independent of piping on steel channel or double angle frames and secure to casing.
    b. Provide frames for maximum of three coil sections.
    c. Arrange supports to avoid piercing drain pans.
    d. Provide airtight seals between coil and casing or duct.
2. Coil Safeguards:
    a. Protect coils to prevent damage to flanges and fins.
    b. Comb out damaged fins.
3. Install all coils level except cleanable coils with 1:50 pitch.
4. Make connections to hydronic and steam coils with unions and flanges.
5. Hydronic (Drainable) Coils:
    a. Connect water supply to leaving air side of coil (counterflow arrangement).
    b. Provide with shut-off valve on supply piping and tamper-proof, balancing valve with memory stop on return piping.
    c. Locate supply water connection on leaving air side at bottom of supply header, and return water connection at top.
    d. Provide manual air vents with stop valves at high points.
        1) Install drain connections at low points of installation.
6. Cooling Coils:
    a. Provide three break or six break moisture eliminators of galvanized 24 gauge, 0.0239 inch sheet steel, where air velocity exceeds 500 ft/min.
    b. Cooling Condensate Drain Pan and Drain Connection:
        1) Fabricate from galvanized 20 gauge, 0.0359 inch sheet steel, extend 3 inches from face of entering air side, 6 inches from the face of the leaving air side, and 4 inches from the face of moisture eliminators.
        2) Design slope in accordance with ASHRAE Std 62.1 and install to prevent standing water.
        3) Pipe drains individually to floor drain with water seal trap.
    c. Install condensate drain pan under each main cooling coil and intermediate condensate drain pan at each level of stacked cooling coils to collect all condensate from coil assembly, pipe header, pipe return bends, upstream run-off, and downstream carry-over.
    d. Insulate bottom of intermediate drain pans for coils mounted in 100 percent outdoor air units with 3/8 inch thick flexible closed cell elastomeric insulation, with the upstream edge protected by stainless steel angle.
        1) Provide rigidly supported, leak-tight copper drain piping from each intermediate pan to pan below.
        2) Flexible Closed Cell Elastomeric Drain Pan Insulation: 3/4"
7. Steam Coils:
    a. Install vacuum breaker in steam line at or in header.
    b. Install steam traps with outlet minimum of 12 inches below coil return connections.
8. Refrigerant Coils:
    a. Provide sight glass in liquid line within 12 inches of coil.

3.3 TERMINAL EQUIPMENT CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in hydronic, steam and condensate, and refrigerant piping systems.

B. Size for supply and return piping connections shall be same as for coil and equipment connections.

C. Install control valves and accessories in accessible locations close to connected equipment.

D. When control valve sizes are smaller than indicated pipe or equipment connection size, provide eccentric reducers on inlet and outlet of control valve.

E. When coil banks are comprised of multiple coils, size individual coil supply and return piping connections same as manufacturer's provided coil connections.

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

G. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping.

H. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping.

I. Provide bypass piping with globe valve around control valve as indicated. If multiple, parallel control valves are installed, only one bypass is required.

J. Provide ports for pressure and temperature gages at coil inlet connections.

K. Connect condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against the pressure of fan. Provide cleanouts in piping at changes of direction.

3.4 FIELD QUALITY CONTROL

A. Provide manufacturer's field representative to test, inspect, instruct, and observe.

3.5 CLEANING

A. After construction and painting is completed, clean exposed surfaces of units.

B. Vacuum clean coils and inside of units.

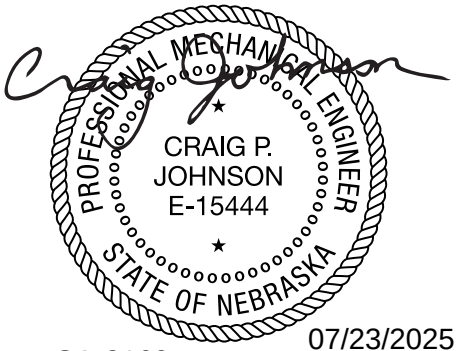
C. Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.

D. Install new filters.

3.6 PROTECTION

A. Provide finished cabinet units with protective covers during the balance of construction.

END OF SECTION



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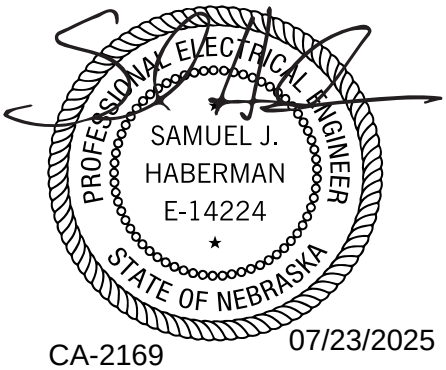

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SECTION 26 04 00

COMMON REQUIREMENTS FOR ELECTRICAL

PART 1 GENERAL

1.1 SUMMARY

A. This section describes the general requirements of these specifications and shall apply to all phases of the work specified, shown on the drawings, or required to provide for complete installation of all systems for this project.

B. This Section includes basic materials and methods to complement other Division 26 Sections.

C. This Section includes basic materials and methods to complement Section 28 46 00 - Fire Detection and Alarm.

1.2 WARRANTIES

A. Warrant materials, workmanship and equipment against defects for a period of one year after the date of substantial completion.

B. Certain equipment shall be warranted beginning at the time of final acceptance or for longer periods of time as specified in those divisions of the Project Manual.

C. Repair or replace, at no additional cost to the Owner, any item which may become defective within the warranty period.

D. Any manufacturers' warranties concerning any item installed will run to the benefit of the Owner.

E. The Contractor agrees not to void or impair, or to allow Sub-Contractors to void or impair, any warranties regarding products or items installed as part of this project.

F. The repair of faulty workmanship shall be considered to be included in the contract.

1.3 ALTERNATES

A. Alternates, if required, shall be as described in the “Alternates” section of this Project Manual, as described on the proposal form, or as indicated on the drawings.

1.4 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

A. If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Engineer for clarification.

B. Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date.

C. Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents.

D. When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.

E. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 CONTRACT DOCUMENT DISCREPANCIES

A. If any ambiguities should appear in the contract documents, request clarification from the Engineer before proceeding with the work.

B. If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Engineer.

C. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Engineer was requested and obtained before submission of proposed methods or materials.

D. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.6 DEFINITIONS

A. The following definitions shall apply throughout the contract documents:
   1. Engineer: Architect or Engineer
   2. Code: Applicable national, state and local codes
   3. Mechanical: Plumbing, HVAC, and Fire Protection work required by the Contract Documents
   4. Electrical: Electrical and Fire Alarm work required by the Contract Documents
   5. Contractor: Any Contractor performing work required by the Contract Documents
   6. Indicated: Noted, scheduled or specified
   7. Selected: Selected by the Engineer.
   8. Provide: Furnish, install, connect and tested complete and ready for use
   9. Furnish: Supply and deliver to the site ready for installation
   10. Install: Install complete, per Contract Documents and manufacturer's requirements.
   11. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
   12. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
   13. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

14. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
15. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
16. Dry Locations: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.
17. Damp Locations: Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture.
    a. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold storage warehouses.
18. Wet Locations: Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.

1.7 SYMBOLS

A. Items of equipment and materials are indicated on the drawings in accordance with the symbols on the plans.

1.8 ABBREVIATIONS

A. Refer to abbreviations list on the Drawings.

B. The following abbreviations apply throughout the Contract Documents:
1. ADA: Americans with Disabilities Act
2. ANSI: American National Standards Institute
3. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers
4. ASME: American Society of Mechanical Engineers
5. ASTM Specification: Standard specifications of the American Society for Testing Materials
6. FM: Factory Mutual Engineering Corporation
7. IRI: Industrial Risk Insurers
8. NEC: National Electrical Code, latest edition
9. NEMA: National Electrical Manufacturers Association
10. NFPA: National Fire Protection Association
11. UL or Underwriters: Underwriters Laboratories, Inc.

1.9 CODES

A. The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards.

B. The work shall conform to all applicable sections of currently adopted editions of the following codes, standards, and specifications:
   1. International Building Code (IBC)
   2. International Fire Code (IFC)
   3. International Energy Conservation Code (IECC)
   4. Safety and Health Regulations for Construction
   5. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards
   6. National Electrical Code (NEC)
   7. National Electrical Safety Code (NESC)
   8. National Fire Protection Association (NFPA)
   9. Life Safety Code (NFPA 101)
   10. Factory Mutual Global Engineering (FMG)
   11. Underwriters' Laboratories, Inc. (UL)
   12. National Electrical Manufacturers Association (NEMA)
   13. Institute of Electrical and Electronics Engineers (IEEE)
   14. Insulated Power Cable Engineers Association (IPCEA)
   15. Telecommunications Industry Association (TIA)
   16. Building Industry Consulting Service International (BICSI)
   17. Applicable national, state and local codes

C. Where there is a conflict between the code and the Contract Documents, the code shall have precedence only when it is more stringent than the Contract Documents.
   1. Items that are allowed by the code but are less stringent than those specified shall not be substituted.

1.10 PERMITS

A. The Contractors shall familiarize themselves with requirements regarding permits, fees, etc., and shall comply with them.

B. Permits, licenses, inspections and arrangements required for the work shall be obtained by the Contractor at his expense.

C. Utilities shall be installed in accordance with the local rules and regulations.

1.11 MATERIALS AND EQUIPMENT MANUFACTURERS

A. Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.

B. Materials and equipment shall be provided in accordance with the following:
   1. Primary Design Products: Primary design products are those products around which the project was designed in terms of capacity, performance, physical size and quality.
   2. Primary design products are indicated by use of a single manufacturer's name, model number or similar data on drawings or schedules or within the specifications.

3. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
4. Acceptable Equivalent Substitutions: Acceptable equivalent substitutions are products of manufacturers other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements:
    a. The product shall be manufactured by one of the acceptable manufacturers listed in the Project Manual, drawings, or addenda.
    b. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
    c. The Contractor providing the substitution shall bear the total cost of changes due to substitutions. These costs may include additional compensation to the Engineer for redesign and evaluation services, increased cost of work by the Owner or other Contractors, and similar considerations.
5. Performance Requirements: Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.
6. Compliance with Standards, Codes and Regulations: Where the specifications require only compliance with an imposed standard, code or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes and regulations.

C. Proposed substitutions will be judged on the basis of quality, performance, appearance and on the governing space limitations. The reputation of the manufacturer, delivery time requirements, and the availability of repair or replacement parts may also be considered.

D. The Engineer shall be the sole and final judge as to the suitability of substitution items.

1.12 SUBMITTALS

A. Shop Drawings, Product Data and Samples:
1. Other sections in the Project Manual shall be adhered to if more stringent than the following paragraphs.
2. When required by other sections of this Project Manual, submit shop drawings, product data or samples to the Engineer for review.
3. Submittals deemed unnecessary by the Engineer shall be returned indicating “No Action Taken”.
4. A completed copy of the transmittal form included with the Project Manual shall accompany each submittal.
5. Submittals shall be numbered consecutively.
6. Unless otherwise noted, submit one copy electronically of shop drawings and product data for review. Review comments will be returned electronically. A hard copy of the electronic submittal will be returned if requested.
7. Where samples are required, submit one (1) sample of each required item.
8. Shop drawings are drawings, diagrams, schedules and other data specifically prepared for this project by the Contractor, Manufacturer, Supplier, or Distributor

to illustrate some portion of the work. Shop Drawings shall also detail fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.

a. Shop drawings shall be drawn to accurate scale and of adequate size to illustrate required details.

9. Product data are illustrations, standard schedules, performance charts, instruction brochures, diagrams and other information furnished by the Contractor, Manufacturer, Supplier, or Distributor to illustrate a material, product or system for some portion of the work.
10. Samples are physical examples furnished by the Contractor, Manufacturer, Supplier, or Distributor to illustrate materials, equipment or workmanship and to establish the standards by which the work will be performed.
11. Each submittal shall clearly indicate proposed items, capacities, characteristics and details in conformance with contract documents. Equipment items shall be marked with the same item number as used on drawings or schedules. Capacities, dimensions and special features required shall be certified by the manufacturer.
12. Submittals shall indicate manufacturer's delivery time for the item after review by the Engineer.
13. The Engineer shall review or take other appropriate action upon the Contractor's submittals such as shop drawings, product data and samples, but only to determine conformance with the design concept of the work and the information given in the contract documents.
14. Contractor shall not be relieved of responsibility for any deviation from the requirements of the contract documents by the Engineer's review of shop drawings, product data or samples.
15. Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Engineer's review of those drawings.
16. No portion of the work requiring submission of a shop drawing, product data or sample shall be commenced until the submittal has been reviewed by the Engineer. Such portions of the work shall be in accordance with reviewed submittals.
17. The successful Contractor/Supplier may, at their option, obtain DXF or AutoCad DWG electronic drawing files for use in preparation of shop drawings.
    a. This information is available from Alvine upon written request.
    b. A non-refundable handling charge of $10.00 per drawing file requested will be required at the time of receipt of the electronic files.
    c. The use of these drawing files is intended solely for the preparation of drawings as required by these contract documents.
    d. Any other use is strictly prohibited by copyright laws.
    e. The user of these electronic drawing files assumes full responsibility for their accuracy and scale.

B. Operation and Maintenance Manuals:

1. Prepare three (3) operation and maintenance manuals for the equipment furnished. Manuals shall be submitted to the Engineer for review and distribution to the Owner not less than 30 days prior to substantial completion of the project.

Manuals not meeting the following requirements may be rejected by the Engineer.

2. Each manual shall be assembled in a three-ring binder with hard cover and plastic finish. Binders shall not exceed a 3-inch thickness. Where more than one binder is required, the manuals shall be separated into a logical grouping, i.e., “Mechanical”, “Electrical”, “Maintenance”, “Operation”, “Parts”, Shop Drawings”, etc. Each binder shall have the following information clearly printed on its front cover:
   a. Project name and address.
   b. Portion of the work covered by each volume (if more than one volume in the set). Where more than one volume is required, label each volume as “Volume _____ of _____”.
   c. Name, address and telephone number of Contractor and Sub-Contractors including night or emergency number.
3. Manual shall include, but shall not be limited to, the following:
   a. A Complete Index. Contractor may submit the index to the Engineer for review prior to submittal of complete manuals if desired.
   b. Names, Addresses and Telephone Numbers. This list shall include the manufacturer and local representative who stocks or furnishes repair parts for all items of equipment and shall be typed on a single page in front of the binder.
   c. Startup, Operation and Shutdown Procedures. Provide a written description of procedures for startup, operation and shutdown of each electrical item or system. This description shall include switches to operate, buttons to push, etc., in proper sequence, and the location of switches, starters, and pushbuttons. Description shall include item references or labels used in the contract documents unless otherwise instructed in advance by the Owner.
   d. Equipment Accessory Schedule. Upon completion of the work, furnish the Owner with a complete equipment accessory schedule listing each piece of equipment and the related size, type, number required and the manufacturer of renewable items.
   e. Manufacturer's Operation and Maintenance Manuals and Parts Lists.
   f. Emergency Procedures. Provide a written description of emergency operating procedures or a list of service organizations (including addresses and telephone numbers) capable of rendering emergency services to the various parts of the system.
   g. One copy of shop drawings and product data, clearly marked for each item furnished using the designation label specified or indicated on Drawings.
   h. Manufacturers' warranty information.
   i. Normal Maintenance Schedule. Include a listing of work to be performed at various time intervals; i.e., 30, 90, 180 days and yearly.

1.13 QUALITY ASSURANCE

A. Conform to the requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.14 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment.
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
   1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

C. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work.

D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces.

E. Coordinate electrical testing of electrical or mechanical items so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.15 STRUCTURAL COORDINATION

A. In cases where the Contractor determines that superimposed loads such as suspended or floor mounted electrical system or equipment exist which exceed design loads indicated on structural contract documents, Contractor shall submit load data to Engineer for review prior to proceeding with work.

B. Distribute the maximum load hung from any structural member for mechanical, electrical, plumbing, ductwork, piping, etc. over the member’s tributary area in a way that the design superimposed dead loads listed in structural contract documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required achieving the allowable load distribution.

C. Connections of systems designed by Contractor’s engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

PART 2 PRODUCTS

2.1 PERFORMANCE, CAPACITIES AND CHARACTERISTICS

A. See Drawings for Equipment Schedules for Equipment Performance Requirements when capacities and characteristics are not indicated in the specifications.

2.2 EQUIPMENT SHORT CIRCUIT CURRENT RATING

A. Where the National Electrical Code or applicable codes require equipment to be marked with a Short Circuit Current Rating (SCCR), the equipment shall be manufactured as required such that the SCCR of the equipment meets or exceeds the available short circuit current at the equipment. Acceptable methods of complying with this requirement are as follows:
   1. Provide SCCR rating at the equipment that meets or exceeds the available short circuit current at the switchboard or panelboard where the equipment circuit originates.
   2. Provide calculations, based on the available short circuit current at the switchboard or panelboard where the equipment circuit originates, that document the actual short circuit current available at the equipment. The SCCR rating of the equipment shall meet or exceed this calculated value.

2.3 MATERIALS

A. Unless otherwise specified, all materials and equipment shall be new, unused and undamaged. Materials and equipment shall be the current and standard designs of manufacturers regularly engaged in their production.

2.4 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

A. Where materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements.

2.5 QUANTITY OF SPECIFIED ITEMS REQUIRED

A. Wherever in these specifications an article, device or piece of equipment is referred to in the singular number; such reference shall apply to as many such articles as are shown on the drawings or required to complete the installation.

2.6 SLEEVES

A. Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

PART 3 EXECUTION

3.1 GENERAL

A. Fabrication, erection, and installation of the complete electrical system shall be done by qualified personnel experienced in such work and shall proceed in an orderly manner so as not to hold up the progress of the project.

B. Check areas and surfaces where electrical equipment or materials are to be installed and report any unsatisfactory conditions before starting work.

C. Commencement of work signifies the Contractor's acceptance of the conditions as fit and proper for the execution of the electrical work.

D. Install equipment and systems in accordance with manufacturer's instructions, requirements, or recommendations.

E. Comply with NECA 1.

F. Unless otherwise noted, measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

G. 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.

H. 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.

I. Right of Way: Give to raceways and piping systems installed at a required slope.

J. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

3.2 DELIVERY AND STORAGE OF MATERIALS

A. Make provisions for the delivery and safe storage of materials.

B. Materials shall be delivered at such stages of the work as will expedite the work as a whole and shall be marked and stored in such a way as to be easily checked and inspected.

C. Adequately protect supplies and equipment during cold weather.

D. Protect items subject to cold weather damage by covering, insulating, or storing in a heated space.

3.3 COOPERATION WITH OTHER CONTRACTORS

A. Perform the electrical work in conformance with the construction called for by other trades and afford other contractors reasonable opportunity for the execution of their work.

B. Properly connect and coordinate the electrical work with the work of other contractors at such time and in such a manner as not to delay or interfere with their work.

C. Examine the contract documents for the General, Mechanical, and Electrical work and the work of other trades. Coordinate work accordingly.

D. Promptly report to the Engineer any delay or difficulties encountered in the installation of the electrical work which might prevent prompt and proper installation of work required from other trades.

3.4 COORDINATION OF WORK

A. Plan work so it proceeds with a minimum of interference with other trades.

B. Inform the General Contractor of all openings required in the building construction for the installation of the electrical work.

C. Cooperate with other contractors in furnishing material and information, in proper sequence, for the correct location of sleeves, inserts, foundations, wiring, etc.

D. Make provisions for special frames, openings, and sleeves as required.

E. The Electrical Contractor shall pay for extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

3.5 LAYING OUT WORK

A. Carefully lay out work in advance of installation using data and measurements from the site, the appropriate architectural drawings, and shop drawings.

B. Confirm code required clearances.

C. Do not infringe upon space required for operation, maintenance, or clearance for items installed by other contractors.

D. Prior to installation of any work, make certain the location does not conflict with other items in or near the same location.

E. If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Engineer prior to installation and request clarification.

F. Failure to properly coordinate and lay out work will require correction by the Contractor at the Contractor’s expense

3.6 DATA AND MEASUREMENTS

A. Mechanical and Electrical drawings are diagrammatic or schematic. Do not scale drawings.

B. The data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed.

C. Obtain exact locations, measurements, levels, etc., at the site and adapt their work to actual conditions.

D. Examine the General Construction, Mechanical, Electrical, and other applicable drawings and the Specifications.

E. Utilize only site measurements in calculations.

F. Layout and coordinate work prior to installation to provide clearances for operation, maintenance and codes. Verify non-interference with other work.

G. Locate outlets and devices mounted on finished surfaces with regard to paneling, furring, trim, etc.

H. Install outlets and devices with vertical edges of plates plumb.

I. Install boxes or plaster rings such that the front edge extends to the finished surface of the wall, ceiling or floor without projecting beyond the surface.

J. Install receptacles, switches, etc., on wood trim, cases, or other fixtures symmetrically and, where necessary, install with the long dimension of the plate horizontal.

K. Coordinate locations of outlets and devices with other contractors so as not to destroy the aesthetic effect of the surface in which the outlets and devices are mounted. Coordinate the locations of electrical items with work furnished by other trades to avoid interference.

L. Heights of outlets are measured from finished floor to centerline of device.

M. Adjust heights as necessary to clear wall-mounted cabinets, fin tube convectors, unit heaters, etc.

N. Mounting heights shall be in compliance with ADA requirements.

O. Install outlets at the heights indicated below unless otherwise noted.
   1. Receptacle outlets (general): 18 inches.
   2. Receptacle outlets (kitchen, utility room, workbenches, etc.): 46 inches.
   3. Pushbuttons: 46 inches.
   4. Fire alarm station: 46 inches.
   5. Fire alarm visual signals and audible/visual signals, wall-mounted: 80 inches to the bottom of the lens unless local code or ADA requirement mandates a lower mounting height.
   6. Fire alarm audible signals, wall-mounted: Match height of audible/visual signals.

P. The mounting heights of disconnect switches, circuit breakers, motor controllers, pushbutton stations and other similar devices and equipment may vary depending upon location and whether individually or group mounted.

Q. For convenience and safety, mount equipment with the center of operating levers, handles or buttons no more than 72 inches above the finished floor.

R. Locate individual devices or pieces of equipment, unless otherwise specified, so the operating handle, lever or button is located approximately 5 feet above finished floor. Coordinate heights of electrical items with work furnished by other trades to avoid interferences.

S. Improperly located devices or outlets shall be relocated by the Contractor at the Contractor's expense including necessary patching.

3.7 PROTECTION OF APPARATUS

A. Take necessary precautions to properly protect apparatus, fixtures, appliances, material, equipment, and installations from damage.

B. Failure to provide such protection to the satisfaction of the Engineer shall be sufficient cause for the rejection of any particular piece(s) of material, apparatus, equipment, etc., concerned.

3.8 SLEEVE INSTALLATION

A. Coordinate sleeve selection and application with selection and application of firestopping.

B. Concrete Slabs and Walls: Install sleeves during erection of slabs and walls. Space sleeves a minimum of three sleeve diameters on center, unless otherwise noted. Sleeves are not required for core-drilled penetrations.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Sleeves through walls: Install flush with both surfaces of wall.

E. Sleeves through floors: Extend 2 inches above finished floor.

F. Sleeves through roofs: Seal with flexible boot-type flashing units applied in coordination with roofing work

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceways or cable unless sleeve seal is to be installed.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.

J. Underground, Exterior-Wall Penetrations: Size sleeves to allow for appropriate clear space between raceway and sleeve for sleeve seals.

3.9 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to maintain fire-resistance rating of assembly.

3.10 WORK IN EXISTING BUILDINGS

A. Execute work in the existing building, indicated on the drawings or specified herein, with a minimum amount of interference with the normal activities of the occupants of the building.

B. Schedule work in advance with the Owner and proceed only with the Owner's written approval.

C. Utilities:
1. Do not interrupt utilities without the Owner's prior written approval regarding the time and duration of such interruptions.
2. Do not disconnect utilities to existing facilities until new or temporary facilities are installed except for short periods of interruption which are necessary for the performance of the new work and which are approved by the Owner.
3. Storm water may be temporarily diverted to surface drainage provided such drainage is arranged to prevent flooding of structures, basements and excavations for construction.

D. Fire Alarm System:
1. As a minimum, maintain the existing degree of protection for all areas throughout construction.
2. Coordinate required outages with the Owner and the Fire Marshal.
3. After any additions or modifications to the fire alarm system, a re-acceptance test shall be performed by a licensed party in accordance with NFPA 72.

E. Welding:
1. Notify the Owner before starting welding or cutting.
2. Fire extinguishers shall be immediately accessible when welding or cutting with an open flame or arc.
3. Stop operations involving welding or cutting with an open flame or arc not less than one hour before leaving the premises.

F. Noisy Operations:
1. Schedule noisy operations, such as those involving use of air hammers, etc., in demolition or cutting of openings, with the Owner.

G. Occupancy:
1. The Owner will continue to occupy the building and carry on normal activity.
2. Protect the occupied areas from dust, smoke, etc., by a method reviewed by the Engineer.

H. Owner's Right to Direct Work: The Owner shall have the right to direct the places of beginning work, its prosecution, and the manner in which all work under this contract is to be conducted, insofar as may be necessary to secure the safe and proper progress and quality of the work.

I. Existing Conduits or Electrical Equipment:

1. Remove or relocate, as required, or as directed by the Engineer, existing conduit or electrical equipment which would interfere with the proper installation of new work.
2. Modify existing work in conformance with these specifications.
3. Use the same materials as for new work unless otherwise specified.

3.11 DEMOLITION AND REMODEL

A. Protect existing electrical equipment and installations indicated to remain.

B. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

C. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

D. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.

E. Remove demolished material from Project site.

F. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

G. Remove existing lights, receptacles, switches, etc., indicated on plans or which are not indicated but must be removed to accommodate demolition or new remodeling.

H. Where existing walls are indicated to be removed, disconnect power to electrical devices and associated appurtenances relating to the walls.

I. Maintain circuit continuity up and down stream from removed outlets.

J. Extend circuiting to up and downstream devices and reconnect as required.

K. Where existing site lighting fixtures are removed, verify the routing of existing circuits. Maintain circuit continuity between existing fixtures which remain.

L. In areas which are remodeled, replace existing wire with new wire. No existing wire is permitted to remain unless noted.

M. Existing concealed conduit and boxes may be reused.

N. Verify existing conditions in field prior to bid date.

3.12 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations.

B. Perform cutting by skilled mechanics of trades involved.

C. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces.

D. Install new fireproofing where existing firestopping has been disturbed.

E. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.13 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work. Repair as necessary.

3.14 CLEANING AND PROTECTION

A. Remove burrs, dirt, paint spots, and construction debris from electrical items.

B. Protect electrical items so that finishes are without damage or deterioration at time of Substantial Completion.

C. All cables and wiring shall be protected from paint. This includes but is not limited to power conductors and feeders, lighting control wiring, and fire alarm cabling. Painted cables shall be replaced in their entirety.

3.15 TEMPORARY POWER AND LIGHTING

A. Provide temporary power and lighting throughout the construction period for the use by all trades, Contractors and Sub-Contractors.

B. Temporary facilities shall be installed in compliance with applicable codes and in compliance with OSHA requirements.

C. Cost of temporary power used during construction, including the cost of setting and removing temporary service, shall be paid by the Contractor.

D. Where existing building electrical system is used to provide temporary power and lighting, energy costs shall be paid by the Owner.

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Single conductor building wire.

B. Wiring connectors.

C. Electrical tape.

D. Heat shrink tubing.

E. Oxide inhibiting compound.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.3 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

A. Provide products that comply with requirements of NFPA 70.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.

D. Comply with NEMA WC 70.

E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.

F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.

G. Conductor Material:
1. Provide copper conductors except where aluminum conductors are specifically indicated. Substitution of aluminum conductors for copper is not permitted. Conductor sizes indicated are based on copper unless specifically indicated as aluminum. Conductors designated with the abbreviation "AL" indicate aluminum.
2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
3. Tinned Copper Conductors: Comply with ASTM B33.
4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated.

H. Minimum Conductor Size:
1. Branch Circuits: 12 AWG.
2. Control Circuits: 14 AWG.

I. Conductor Color Coding:
1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
2. Color Coding Method: Integrally colored insulation.
a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
3. Color Code:
a. 208Y/120 V, 3 Phase, 4 Wire System:
1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.
4) Neutral/Grounded: White.
b. Equipment Ground, All Systems: Green.
c. For control circuits, comply with manufacturer's recommended color code.

2.2 SINGLE CONDUCTOR BUILDING WIRE

A. Description: Single conductor insulated wire.

B. Conductor Stranding:
1. Feeders and Branch Circuits:
a. Size 10 AWG and Smaller: Solid.
b. Size 8 AWG and Larger: Stranded.

C. Insulation Voltage Rating: 600 V.

D. Insulation:
1. Copper Building Wire: Type THHN/THWN, THHN/THWN-2, or XHHW-2, except as indicated below.
a. Installed Underground: Type XHHW-2 or THHN/THWN-2.

2.3 WIRING CONNECTORS

A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

B. Wiring Connectors for Splices and Taps:
1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.

C. Wiring Connectors for Terminations:
1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
2. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.

D. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.

E. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.

F. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.

G. Mechanical Connectors: Provide bolted type or set-screw type.

H. Compression Connectors: Provide circumferential type or hex type crimp configuration.

2.4 ACCESSORIES

A. Electrical Tape:
1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion,

corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.

B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.

C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that interior of building has been protected from weather.

B. Verify that work likely to damage wire and cable has been completed.

C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.

D. Verify that field measurements are as indicated.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.3 INSTALLATION

A. Circuiting Requirements:
   1. When circuit destination is indicated without specific routing, determine exact routing required.
   2. Install service and feeder conductors unspliced unless otherwise indicated.
   3. Arrange branch circuiting to minimize splices.
   4. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
   5. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
   6. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is permitted, under the following conditions:
      a. Provide no more than 6 #12 AWG current-carrying conductors in 1/2 inch conduit; 9 #12 AWG current-carrying conductors in 3/4 inch conduit.
      b. Provide no more than 6 #10 AWG current-carrying conductors in 3/4 inch conduit; 9 #10 AWG current-carrying conductors in 1 inch conduit.
      c. Provide no more than 4 #8 AWG current-carrying conductors in 3/4 inch conduit; 6 #8 AWG current-carrying conductors in 1 inch conduit; 9 #8 AWG current-carrying conductors in 1-1/4 inch conduit.

7. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.

B. Install products in accordance with manufacturer's instructions.

C. Perform work in accordance with NECA 1 (general workmanship).

D. Install aluminum conductors in accordance with NECA 104.

E. Installation in Raceway:
1. Pull all conductors and cables together into raceway at same time.
2. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
3. Use suitable wire pulling lubricant where necessary, except as below:
   a. Do not use when lubricant is not recommended by the conductor manufacturer.

F. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.

G. Install conductors with a minimum of 6 inches of slack at each outlet.

H. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

I. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.

J. Make wiring connections using specified wiring connectors.
1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies.
2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
3. Do not remove conductor strands to facilitate insertion into connector.
4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.
6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

K. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.

1. Dry Locations: Use insulating covers specifically designed for the connectors or heat shrink tubing.
2. Damp Locations: Use insulating covers specifically designed for the connectors or heat shrink tubing.
    a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
3. Wet Locations: Use heat shrink tubing.

L. Insulate ends of spare conductors using vinyl insulating electrical tape.

M. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.

N. Identify conductors and cables in accordance with Section 26 05 53.

O. Install firestopping to preserve fire resistance rating of partitions and other elements.

P. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Grounding and bonding requirements.

B. Conductors for grounding and bonding.

C. Connectors for grounding and bonding.

D. NECA 1 - Standard for Good Workmanship in Electrical Construction.

E. NFPA 70 - National Electrical Code.

F. UL 467 - Grounding and Bonding Equipment.

G. TIA/EIA-607 - Commercial Building Grounding and Bonding Requirements for Telecommunications

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.3 DEFINITIONS

A. ACEG: Alternating Current Equipment Ground

B. BCT: Bonding Conductor for Telecommunications (formerly Telecommunications Bonding Conductor)

C. BBC: Backbone Bonding Conductor (formerly Grounding Equalizer)

D. PBB: Primary Bonding Busbar (formerly Telecommunications Main Grounding Busbar)

E. SBB: Secondary Bonding Busbar (formerly Telecommunications Grounding Busbar)

F. TBB: Telecommunications Bonding Backbone

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Comply with TIA/EIA-607 for telecommunications grounding.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 GROUNDING AND BONDING REQUIREMENTS

A. Do not use products for applications other than as permitted by NFPA 70 and product listing.

B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.

C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

D. Bonding and Equipment Grounding:
   1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
   2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
   3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
   4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
   5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
   6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.

2.2 GROUNDING AND BONDING COMPONENTS

A. General Requirements:
   1. Provide products listed, classified, and labeled as suitable for the purpose intended.
   2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 05 26:
   1. Use insulated copper conductors unless otherwise indicated.
      a. Exceptions:
         1) Use bare tinned copper conductors where installed underground in direct contact with earth.

2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections, high-pressure compression conections, or high-pressure compression conections for underground, concealed and other inaccessible connections.
3. Unless otherwise indicated, use compression connectors for accessible connections. For #6 AWG and smaller, use one-hole lugs. For #4 AWG and larger, use two-hole lugs.
a. Exceptions:
1) Use exothermic welded connections or high-pressure compression connections for connections to metal building frame.
4. Manufacturers - High-Pressure Compression Connectors:
a. Burndy: www.burndy.com; Hyground System
b. Thomas & Betts: www.tnb.com.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that work likely to damage grounding and bonding system components has been completed.

B. Verify that field measurements are as indicated.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Install each bonding conductor in a direct route, and parallel or perpendicular to building structure or surfaces, without interfering with other systems or equipment.

D. Install exterior grounding electrode conductors with a minimum bending radius of 12 inches.

E. Install interior grounding conductors with a minimum bending radius of 8 inches.

F. Install grounding conductors in EMT conduit unless otherwise indicated. Bond each end of the conduit to the grounding conductor using an appropriate grounding bushing.

G. Make grounding and bonding connections using specified connectors.

1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

H. Identify grounding and bonding system components in accordance with Section 26 05 53.
1. Clean each surface prior to attachment of label.
2. Follow manufacturer's recommendations for affixing labels.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.2 REFERENCE STANDARDS

A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

D. MFMA-4 - Metal Framing Standards Publication.

E. NECA 1 - Standard for Good Workmanship in Electrical Construction.

F. NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.
   2. Coordinate work to provide additional framing and materials required for installation.
   3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
   4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
   5. Notify Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
   1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:
1. Comply with the following. Where requirements differ, comply with most stringent.
a. NFPA 70.
b. Requirements of authorities having jurisdiction.
2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of electrical work.
3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
6. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
7. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Conduit and Cable Supports: Straps and clamps suitable for conduit or cable to be supported.
1. Conduit Straps: One-hole or two-hole type; steel.
2. Conduit Clamps: Bolted type unless otherwise indicated.

C. Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.

D. Metal Channel/Strut Framing Systems:
1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
2. Comply with MFMA-4.
3. Channel Material:
a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.

E. Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.

F. Anchors and Fasteners:
1. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.

2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
4. Hollow Masonry: Use toggle bolts, expansion anchors, or expansion anchors.
5. Hollow Stud Walls: Use toggle bolts.
6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7. Sheet Metal: Use sheet metal screws.
8. Wood: Use wood screws.

G. Cable Supports for Vertical Conduit: Factory-fabricated body with insulated wedging plug, appropriately sized for conductors being supported.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install hangers and supports in accordance with NECA 1.

C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

D. Unless specifically indicated or approved by Engineer, do not provide support from suspended ceiling support system or ceiling grid.

E. Unless specifically indicated or approved by Engineer, do not provide support from roof deck.

F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

G. Equipment Support and Attachment:
1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
2. Use metal channel (strut) secured to studs to support equipment surface-mounted on walls when wall strength is not sufficient to resist pull-out.
3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3-1/2 inch high concrete pad.
5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
6. Install surface-mounted cabinets and panelboards with minimum of four anchors.

H. Secure fasteners in accordance with manufacturer's recommended torque settings.

I. Remove temporary supports.

J. Identify independent electrical component support wires above accessible ceilings, where permitted, with color distinguishable from ceiling support wires in accordance with NFPA 70.

3.3 FIELD QUALITY CONTROL

A. Inspect support and attachment components for damage and defects.

B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

C. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 26 05 33.13

CONDUIT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Flexible metal conduit (FMC).

B. Liquidtight flexible metal conduit (LFMC).

C. Galvanized steel electrical metallic tubing (EMT).

D. Rigid polyvinyl chloride (PVC) conduit.

E. Accessories.

1.2 REFERENCE STANDARDS

A. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S).

B. NECA 1 - Standard for Good Workmanship in Electrical Construction.

C. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC).

D. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.

E. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit.

F. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.

G. NFPA 70 - National Electrical Code.

H. UL 1 - Flexible Metal Conduit.

I. UL 360 - Liquid-Tight Flexible Metal Conduit.

J. UL 514B - Conduit, Tubing, and Cable Fittings.

K. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.

L. UL 797 - Electrical Metallic Tubing-Steel.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate minimum sizes of conduits with actual type and quantity of conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate arrangement of conduits with structural members, ductwork, piping, equipment, and other potential conflicts.
3. Verify exact conduit termination locations required for boxes, enclosures, and equipment.
4. Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.
5. Notify Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
1. Do not begin installation of conductors and cables until installation of conduit between termination points is complete.

1.4 DEFINITIONS

A. Telecommunications Pathway: Any item, raceway, box or enclosure in which telecommunications cabling is placed.

1.5 QUALITY ASSURANCE

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUIT APPLICATIONS

A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, manufacturer's instructions, and product listing.

B. Outdoor Underground Installations:
1. Unless otherwise indicated, use rigid non-metallic conduit

C. Outdoor Locations Above Grade: Use electrical metallic tubing.

D. In Slab Above Grade or Beneath Slab-on-Grade:
1. Use rigid non-metallic conduit.

E. Dry Locations:
1. Concealed: Use electrical metallic tubing.
2. Exposed: Use electrical metallic tubing.

F. Connection to Motors: Use liquid-tight flexible metal conduit, except use flexible metal conduit in air plenums.

G. Connection to Vibrating Equipment (including transformers):

1. Indoors: Use flexible metal conduit.
2. Outdoors: Use liquid-tight flexible metal conduit.

2.2 CONDUIT - GENERAL REQUIREMENTS

A. Comply with NFPA 70.

B. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from corrosion, and integrity is verified by pulling mandrel through them.

C. Provide conduit, fittings, supports, and accessories required for complete raceway system.

D. Provide products listed, classified, and labeled as suitable for purpose intended.

E. Minimum Conduit Size, Unless Otherwise Indicated:
1. Branch Circuits: 1/2-inch trade size.
2. Branch Circuit Homeruns: 3/4-inch trade size.
3. Control Circuits: 1/2-inch trade size.

F. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.3 FLEXIBLE METAL CONDUIT (FMC)

A. Description: NFPA 70, Type FMC standard-wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems.

B. Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel, malleable iron, or die cast zinc.

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360; rated for use with conductors rated 75 degrees C.

B. Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel, malleable iron, or die cast zinc.

2.5 GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)

A. Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

B. Colored EMT:
   1. Manufacturer: Allied Tube and Conduit.
   2. Color Code:
      a. Fire Alarm: Red
      b. HVAC Controls: Black / Flat Black (Public Exposed Areas)
      c. Normal Branch: Black / Flat Black (Public Exposed Areas)

C. Fittings:
   1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   2. Material: Use steel, malleable iron, or die cast zinc.
   3. Connectors and Couplings: Use compression/gland or set-screw type.
      a. Do not use indenter type connectors and couplings.
   4. Damp or Wet Locations, Where Permitted: Use fittings listed for use in wet locations.

2.6 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

A. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.

B. Fittings:
   1. Manufacturer: Same as manufacturer of conduit to be connected.
   2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.7 ACCESSORIES

A. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.

B. Pull Strings: Use nylon or polyester tape with average breaking strength of not less than 200 lbf.

C. Foam Conduit Sealant:
   1. Removable, two-part, closed-cell foam, specifically designed for sealing conduit openings against water, moisture, gases, and dust.
   2. Suitable for use with conductors/cables and associated insulation/jackets to be installed.
   3. Rated to hold minimum of 10 ft water head pressure.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive conduits.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install conduit in accordance with NECA 1.

C. Rigid Polyvinyl Chloride (PVC) Conduit: Install in accordance with NECA 111.

D. Conduit Routing:
1. Unless dimensioned, conduit routing indicated is diagrammatic.
2. When conduit destination is indicated without specific routing, determine exact routing required.
3. Conceal conduits unless specifically indicated to be exposed.
4. Conduits in the following areas may be exposed, unless otherwise indicated:
   a. Electrical rooms.
   b. Mechanical equipment rooms.
5. Unless otherwise approved, do not route exposed conduits:
   a. Across floors.
   b. Across roofs.
   c. Across top of parapet walls.
   d. Across building exterior surfaces.
6. Arrange conduit to maintain adequate headroom, clearances, and access.
7. Arrange conduit to provide no more than equivalent of four 90-degree bends between pull points.
8. Exterior Branch Circuits: Route conduits adjacent to curbs. Push or directional bore conduits beneath paved areas; otherwise, sawcut and remove pavement. Replace removed pavement to match existing.
9. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
10. Maintain minimum clearance of 12 inches between conduits and hot surfaces.
11. Group parallel conduits in same area on common rack.

E. Conduit Support:
1. Secure and support conduits in accordance with NFPA 70 using suitable supports and methods approved by authorities having jurisdiction; see Section 26 05 29.
   a. Support PVC conduit within 3 feet of termination points and at intervals not exceeding those listed below in accordance with NFPA 70 Table 352.30.
      1) 1/2" to 1" trade size = 3 feet spacing between supports.
      2) 1-1/4" to 2" trade size = 5 feet spacing between supports.
      3) 2-1/2" to 3" trade size = 6 feet spacing between supports.
      4) 3-1/2" to 5" trade size = 7 feet spacing between supports.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
4. Use of spring steel conduit clips for support of conduits is permitted only as follows:
    a. Support of electrical metallic tubing (EMT)1-1/2 inch trade size concealed above accessible ceilings and within hollow stud walls.
5. Use of wire for support of conduits is permitted only as follows:
    a. For suspending conduits supported by spring steel conduit clips, where specifically indicated or permitted.

F. Connections and Terminations:
1. Use suitable adapters where required to transition from one type of conduit to another.
2. Provide insulated bushings on box connectors 1-inch and larger, on conduits stubbed above an accessible ceiling, and on conduits used for telecommunications pathways.
3. Secure joints and connections to provide mechanical strength and electrical continuity.

G. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.
3. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
4. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty.
5. Install firestopping to preserve fire resistance rating of partitions and other elements.

H. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
2. Where change in length, calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground, is expected to be 1/4 inch or greater between securely mounted items such as boxes, cabinets, elbows, or other conduit terminations, which includes the following conditions:
    a. 100 foot intervals within spaces that have an ambient temperature range of 0-5 degrees Fahrenheit or less.
    b. 60 foot intervals within spaces that have an ambient temperature range of 5-10 degrees Fahrenheit or less.
    c. 40 foot intervals within spaces that have an ambient temperature range of 10-15 degrees Fahrenheit or less.
3. Where conduits are subject to earth movement by settlement or frost.

I. Conduit Sealing:
   1. Use foam conduit sealant to prevent entry of moisture and gases. This includes, but is not limited to:
      a. Where conduits enter building from outside.
      b. Where service conduits enter building from underground distribution system.
      c. Where conduits enter building from underground.
      d. Where conduits may transport moisture to contact live parts.
   2. Where conduits cross barriers between areas of potential substantial temperature differential, use foam conduit sealant, junction box, or type C condulet at accessible point near penetration to prevent condensation. This includes, but is not limited to:
      a. Where conduits pass from outdoors into conditioned interior spaces.
      b. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.

J. Provide pull string in each empty conduit and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.

K. Provide grounding and bonding; see Section 26 05 26.

L. Identify conduits; see Section 26 05 53.

3.3 FIELD QUALITY CONTROL

A. Correct deficiencies and replace damaged or defective conduits.

3.4 CLEANING

A. Clean interior of conduits to remove moisture and foreign matter.

3.5 PROTECTION

A. Immediately after installation of conduit, use suitable caps to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION

SECTION 26 05 33.16

BOXES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.

B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.

1.2 REFERENCE STANDARDS

A. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

B. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.

C. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

D. NFPA 70 - National Electrical Code.

E. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

F. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.

G. UL 508A - Industrial Control Panels.

H. UL 514A - Metallic Outlet Boxes.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
   4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
   5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
   6. Coordinate the work with other trades to preserve insulation integrity.
   7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.

8. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 BOXES

A. General Requirements:
1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
3. Provide products listed, classified, and labeled as suitable for the purpose intended.
4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
5. Provide grounding terminals within boxes where equipment grounding conductors terminate.

B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
3. Use suitable concrete type boxes where flush-mounted in concrete.
4. Use suitable masonry type boxes where flush-mounted in masonry walls.
5. Use raised covers suitable for the type of wall construction and device configuration where required.
6. Do not use "through-wall" boxes designed for access from both sides of wall.
7. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
8. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
9. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
10. Minimum Box Size, Unless Otherwise Indicated:
    a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-1/2 inch deep (100 by 38 mm) trade size.
    b. Communications Systems Outlets: 4 inch square by 2-1/8 inch deep trade size.
    c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.
11. Wall Plates: Comply with Section 26 27 26.

C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
   1. Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
   2. NEMA EN 10250 Environment Type, Unless Otherwise Indicated:
      a. Indoor Clean, Dry Locations: Type 1, painted steel.
      b. Outdoor Locations: Type 3R, painted steel.
   3. Junction and Pull Boxes Larger Than 100 cubic inches:
      a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
      b. Include cable supports if any dimension of the box is greater than 48 inches.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive boxes.

C. Verify that conditions are satisfactory for installation prior to starting work.

D. Verify locations of floor boxes prior to rough-in.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.

E. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.

F. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.

G. Box Locations:
   1. Locate boxes to be accessible. Provide access panels as required where approved by the Architect.
   2. Unless dimensioned, box locations indicated are approximate.
   3. Locate boxes as required for devices installed under other sections or by others.
   4. Locate boxes so that wall plates do not span different building finishes.
   5. Locate boxes so that wall plates do not cross masonry joints.

6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
8. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.
9. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
    a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
10. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 05 33.13.
11. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
    a. Concealed above accessible suspended ceilings.
    b. Within joists in unfinished areas with no ceiling.
    c. Electrical rooms.
    d. Mechanical equipment rooms.

H. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
4. Use far-side support to secure flush-mounted boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.

I. Install boxes plumb and level.

J. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.

K. Install boxes as required to preserve insulation integrity.

L. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

M. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.

N. Close unused box openings.

O. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.

P. Provide grounding and bonding in accordance with Section 26 05 26.

Q. Identify boxes in accordance with Section 26 05 53.

R. Orient boxes to accommodate wiring devices oriented as specified in Section 26 27 26.

S. Orient each box located above an accessible ceiling so the box opening faces down or to one side.

T. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

U. Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.

V. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.

3.3 CLEANING

A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical identification requirements.

B. Identification nameplates and labels.

C. Identification for conductors.

D. Warning signs and labels.

1.2 REFERENCE STANDARDS

A. ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs.

B. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels.

C. NFPA 70 - National Electrical Code.

D. NFPA 70E - Standard for Electrical Safety in the Workplace.

1.3 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 IDENTIFICATION REQUIREMENTS

A. Identification for Equipment:
   1. Use identification nameplate to identify electrical equipment.
      a. Panelboards:
         1) Identify panelboard name.
         2) Identify power source and circuit number. Include location when not within sight of equipment.
         3) Use typewritten circuit directory to identify load(s) served for panelboards with a door.
         4) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device.
      b. Enclosed switches, circuit breakers, and motor controllers:
         1) Identify power source and circuit number. Include location when not within sight of equipment.
         2) Identify load(s) served.
   2. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".

3. Available Fault Current Documentation: Use identification nameplate to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.
4. Arc Flash Hazard Warning Labels: Use warning labels to identify arc flash hazards for electrical equipment indicated.
    a. Legend: Include orange header that reads "WARNING", followed by the word message "Arc Flash and Shock Hazard; Appropriate PPE Required; Do not operate controls or open covers without appropriate personal protection equipment; Failure to comply may result in injury or death; Refer to NFPA 70E for minimum PPE requirements" or approved equivalent.

B. Identification for Conductors and Cables:
1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 05 19.
2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.

C. Identification for Raceways:
1. Use factory-painted conduits to identify specified systems for accessible conduits.
    a. Color Code:
        1) Normal Power System and HVAC Control System: Match Existing Conduit Color. Black / Flat Black (Exhibit Exposed Spaces) .

D. Identification for Boxes:
1. Use color coded boxes or color-coded box covers to identify specified systems.
    a. Color-Coded Box Covers: Field-painted with two coats of enamel paint per the color code below:
        1) Fire Alarm System: Red.
    b. For exposed boxes in public areas, flat black to blend in with ceiling color.
2. Use handwritten text using indelible marker to identify circuits enclosed.
    a. For exposed boxes in public areas, provide identification on inside face of cover.

E. Identification for Devices:
1. Wiring Device and Wallplate Finishes: Comply with Section 26 27 26.

2.2 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:
1. Materials:
    a. Indoor Clean, Dry Locations: Use plastic nameplates.

2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
    a. Color: White text on black background.

B. Identification Labels:
1. Manufacturers:
    a. Brady Corporation: www.bradyid.com/#sle.
    b. Brother International Corporation: www.brother-usa.com/#sle.
    c. Panduit Corp: www.panduit.com/#sle.
2. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
    a. Use only for indoor locations.
3. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
4. Color: Black text on clear background. Provide black text on white background when applying to a dark surface.

C. Format for Equipment Identification:
1. Minimum Size:
    a. Plastic Nameplates: 1 inch by 2.5 inches.
    b. Identification Labels: 0.5 inch by 2.5 inches.
2. Minimum Size: 1 inch by 2.5 inches.
3. Legend:
    a. Equipment designation or other approved description.
4. Text: All capitalized unless otherwise indicated.
5. Minimum Text Height:
    a. Equipment Designation: 3/8 inch.

2.3 WARNING SIGNS AND LABELS

A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.

B. Warning Labels:
1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
   1. Surface-Mounted Equipment: Enclosure front.
   2. Flush-Mounted Equipment: inside of equipment door when installed in a finished location.
   3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
   4. Elevated Equipment: Legible from the floor or working platform.
   5. Boxes: Outside face of cover.
   6. Devices: Outside face of cover.

C. Install identification products centered, level, and parallel with lines of item being identified.

D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws or self-adhesive backing and to interior surfaces using self-adhesive backing.

E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

F. Mark all handwritten text, where permitted, to be neat and legible.

3.3 FIELD QUALITY CONTROL

A. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

SECTION 26 05 83

WIRING CONNECTIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electrical connections to equipment.

1.2 REFERENCE STANDARDS

A. NEMA WD 6 - Wiring Devices - Dimensional Specifications.

B. NFPA 70 - National Electrical Code.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
2. Determine connection locations and requirements.

B. Sequencing:
1. Install rough-in of electrical connections before installation of equipment is required.
2. Make electrical connections before required start-up of equipment.

1.4 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.1 MATERIALS
1. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
2. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

C. Provide receptacle outlet to accommodate connection with attachment plug.

D. Provide cord and cap where field-supplied attachment plug is required.

E. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

F. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

G. Provide final power and control connections for equipment furnished under other Divisions of this specification and for Owner-furnished equipment. Where not specified in mechanical sections of this specification, connect motor controls and associated mechanical equipment as required for a complete and functional control system.

H. Provide interlocks and wiring to and between controls for Owner-furnished equipment, rooftop units, condensing units, fan coil units, energy management system, and elevator life safety panels.

I. Verify control wiring requirements with manufacturer certified shop drawings for each piece of equipment or control system and install accordingly. Install control wiring in conduit.

3.3 EQUIPMENT REQUIREMENTS

A. Temperature Control / Energy Management System Panels:
   1. Provide a dedicated power circuit from the nearest 120 V general purpose panel to each temperature control, energy management system, or data gathering panel.
   2. Coordinate panel quantities and locations with Installing Contractor.

B. Electric Duct Heaters:
   1. Provide step power and control conductors from control cabinet to duct heater where duct heater control cabinet is remote from the heater. Wire safety controls from heater to control cabinet.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Lighting and appliance panelboards.

B. Overcurrent protective devices for panelboards.

1.2 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction.

B. NECA 407 - Standard for Installing and Maintaining Panelboards.

C. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

D. NEMA PB 1 - Panelboards.

E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

F. NFPA 70 - National Electrical Code.

G. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

H. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.

I. UL 67 - Panelboards.

J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.

K. UL 943 - Ground-Fault Circuit-Interrupters.

L. UL 1699 - Arc-Fault Circuit-Interrupters.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.

4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.

B. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.

C. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.

D. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Panelboard Keys: six of each different key.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. ABB/GE: www.electrification.us.abb.com.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier, where possible.

2.2 PANELBOARDS - GENERAL REQUIREMENTS

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature:
      a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
      b. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.

C. Short Circuit Current Rating:
   1. Provide panelboards with listed short circuit current rating as indicated on the drawings. Where the available fault current is indicated, provide panelboards with listed short circuit current rating not less than the available fault current.
   2. Listed series ratings are acceptable only where specifically indicated.
   3. Label equipment utilizing series ratings as required by NFPA 70.

D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation. Do not reduce panelboard pole quantity or mounting spaces indicated on drawings by installation of branch-mounted main device, where used. Provide additional poles or spaces as required.

E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
   1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
   2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.

G. Conductor Terminations: Suitable for use with the conductors to be installed.

H. Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
   2. Boxes: Galvanized steel unless otherwise indicated.

a. Provide wiring gutters sized to accommodate the conductors to be installed.

3. Fronts:
   a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
   b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
   c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
4. Lockable Doors: All locks keyed alike unless otherwise indicated.

I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

J. Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.

2.3 LIGHTING AND APPLIANCE PANELBOARDS

A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B. Conductor Terminations:
1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
2. Main and Neutral Lug Type: Mechanical.

C. Bussing:
1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
2. Phase and Neutral Bus Material: Aluminum or copper.
3. Ground Bus Material: Aluminum or copper.

D. Circuit Breakers: Thermal magnetic bolt-on type.

E. Enclosures:
1. Provide surface-mounted or flush-mounted enclosures as indicated.
2. Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
3. Provide clear plastic circuit directory holder mounted on inside of door.
4. Minimum dimensions: 5-1/2 inches deep, 20 inches wide.

2.4 OVERCURRENT PROTECTIVE DEVICES

A. Molded Case Circuit Breakers:
1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
2. Interrupting Capacity:

a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
   1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
   2) 14,000 rms symmetrical amperes at 480 VAC.
b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.

3. Conductor Terminations:
   a. Provide mechanical lugs unless otherwise indicated.
   b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
   a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
6. Provide the following circuit breaker types where indicated:
   a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
   b. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
7. Provide listed switching duty rated circuit breakers with SWD marking for all branch circuits serving fluorescent lighting.
8. Provide listed high intensity discharge lighting rated circuit breakers with HID marking for all branch circuits serving HID lighting.
9. Do not use tandem circuit breakers.
10. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.
11. Provide the following features and accessories where indicated or where required to complete installation:
   a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive panelboards.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Perform work in accordance with NECA 1 (general workmanship).

B. Install products in accordance with manufacturer's instructions.

C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

E. Provide required support and attachment in accordance with Section 26 05 29.

F. Install panelboards plumb.

G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.

H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.

I. Provide minimum of five spare 3/4 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling.

J. Provide grounding and bonding in accordance with Section 26 05 26.

K. Install all field-installed branch devices, components, and accessories.

L. Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by NFPA 70.

M. Set field-adjustable ground fault protection pickup and time delay settings as indicated.

N. Provide filler plates to cover unused spaces in panelboards.

O. Identify panelboards in accordance with Section 26 05 53.

P. If the overcurrent protection for a panelboard feeder is less than the nameplate rating of the panelboard, provide a plastic nameplate indicating the ampacity of the feeder circuit. Attach nameplate to the inside of the panelboard so it is visible when the panelboard door is opened.

Q. Connections:
   1. Connect phase conductors A, B, C left to right as viewed from the front of the panel unless bus bars are factory labeled otherwise.
   2. Connect each branch circuit served by a lighting and appliance branch circuit panelboard to a 20A 1-pole breaker unless otherwise indicated.
   3. Circuit numbering indicated for lighting and appliance branch circuit panelboards is based on pole position within the panelboard. For multipole breakers, the circuit number corresponds to the first pole position occupied by the breaker.
   4. Circuit number indicated for distribution panelboards is based on consecutive numbering.

3.3 FIELD QUALITY CONTROL

A. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.

B. Test GFCI circuit breakers to verify proper operation.

C. Test AFCI circuit breakers to verify proper operation.

D. Test shunt trips to verify proper operation.

E. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of panelboard fronts.

3.5 CLEANING

A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Receptacles.

B. Device plates and box covers.

1.2 REFERENCE STANDARDS

A. NEMA WD 1 - General Color Requirements for Wiring Devices.

B. NEMA WD 6 - Wiring Devices - Dimensional Specifications.

C. NFPA 70 - National Electrical Code.

D. UL 498 - Attachment Plugs and Receptacles.

E. UL 514D - Cover Plates for Flush-Mounted Wiring Devices.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
   2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
   3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
   4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
   5. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

B. Sequencing:
   1. Do not install wiring devices until final surface finishes and painting are complete.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.6 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS

2.1 WIRING DEVICES - GENERAL REQUIREMENTS

A. Provide wiring devices suitable for intended use with ratings adequate for load served.

2.2 MANUFACTURERS

A. Cooper Wiring Devices: www.cooperwiringdevices.com.

B. Hubbell Incorporated: www.hubbell-wiring.com.

C. Leviton Manufacturing Company, Inc: www.leviton.com.

D. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us

E. Source Limitations: Where possible, provide products for each type of wiring device produced by a single manufacturer and obtained from a single supplier.

2.3 WIRING DEVICE FINISHES

A. Device Color: Gray unless otherwise indicated or required by code; brown in dark brick, wood paneled or dark-finished walls.

2.4 RECEPTACLES

A. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498; types as indicated on the drawings.
   1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
   2. NEMA configurations specified are according to NEMA WD 6.

B. Acceptable products are listed below for specific device types.

C. Straight Blade Receptacles: 20A, 125V.

Description	Cooper	Hubbell	Leviton	P & S
Simplex	1877	HBL5361	5891	5361
Duplex	BR20	BR20	5362	CRB5362
Duplex tamper resistant	TRBR20	BR20TR	T5362	TR5362
Duplex GFCI	SGF20	GFRST20	GFNT2	2097
Duplex GFCI tamper resistant	TRSGF20	GFTRST20	GFTR2	2097TR

Duplex GFCI weather resistant	WRSGF20	GFRWR20	GFWT2	2097TRWR
Duplex GFCI weather resistant, tamper resistant	WRSGF20	GFRTW20	GFWR2	2097TRWR
Duplex isolated ground	IG5362	IG20CR	5362-IG	IG5362
Duplex tamper resistant with USB-A and USB-C charging ports	TRUSBAC20	USB20AC5	T5833	TR20USBAC6
Duplex TVSS	5362S	HBL5362SA	7380	5362SP
Clock hanger	775V	RR151CHI	688	S3713

2.5 WALL PLATES AND COVERS

A. Wall Plates: Comply with UL 514D.
   1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
   2. Screws: Metal with slotted heads finished to match wall plate finish.

B. Wall Plates for Flush Devices: Type 302 or 304, satin finished stainless steel, minimum thickness 0.03 inches.

C. Weatherproof Receptacle Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

C. Verify that wall openings are neatly cut and will be completely covered by wall plates.

D. Verify that final surface finishes are complete, including painting.

E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

F. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

A. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of wiring devices provided under this section.
   1. Provide minimum of 24 inches horizontal separation between flush mounted outlet boxes installed on opposite sides of fire rated walls.
   2. Where multiple devices are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
   3. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.

B. Install wiring devices in accordance with manufacturer's instructions.

C. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

D. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.

E. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

F. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices unless otherwise indicated.

G. Install wiring devices plumb and level with mounting yoke held rigidly in place.

H. Install vertically mounted receptacles with grounding pole on bottom.

I. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

J. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.

K. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas and above accessible ceilings.

3.4 FIELD QUALITY CONTROL

A. Inspect each wiring device for damage and defects.

B. Operate each fan speed controller with circuit energized to verify proper operation.

C. Test each receptacle to verify operation and proper polarity.

D. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.

E. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.5 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.6 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Fuses.

1.2 REFERENCE STANDARDS

A. NEMA FU 1 - Low Voltage Cartridge Fuses.

B. NFPA 70 - National Electrical Code.

C. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.
3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.

B. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Fuses: One of each type and size, unless a greater quantity is indicated on drawings.
2. Fuse Pullers: One set(s) compatible with each type and size installed.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Bussmann, a division of Eaton Corporation: www.cooperindustries.com/#sle.

B. Littelfuse, Inc: www.littelfuse.com/#sle.

C. Mersen: ep-us.mersen.com/#sle.

2.2 APPLICATIONS

A. Fuses 600 Amps or Smaller: Class RK1, time delay, equivalent to Bussmann Low Peak. Provide with open fuse indication where avialable.

B. Plug Fuses: Class S, time delay, equivalent to Bussmann Fustat. Provide with a Bussmann catalog number SSY device cover incorporating a switch and fuse holder. Where a lockable switch is required, provide a Bussmann catalog number SOY box cover with fuse holder mounted adjacent to a locking toggle switch.

2.3 FUSES

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.

C. Provide fuses of the same type, rating, and manufacturer within the same switch.

D. Comply with UL 248-1.

E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.

F. Voltage Rating: Suitable for circuit voltage.

G. Provide the following accessories where indicated or where required to complete installation:
   1. Fuseholders: Compatible with indicated fuses.
   2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.

B. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Do not install fuses until circuits are ready to be energized.

B. For motor circuits, provide fuses rated at 125 percent of motor nameplate full load current.

C. Install fuses with label oriented such that manufacturer, type, and size are easily read.

END OF SECTION

SECTION 26 28 16.16

ENCLOSED SWITCHES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Enclosed safety switches.

1.2 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction.

B. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. NEMA BS 31047 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).

D. NFPA 70 - National Electrical Code.

E. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

F. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.

G. UL 98 - Enclosed and Dead-Front Switches.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   4. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.

B. Project Record Documents: Record actual locations of enclosed switches.

C. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.5 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. ABB/GE: www.electrification.us.abb.com.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier, where possible.

2.2 ENCLOSED SAFETY SWITCHES

A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature: Between -22 degrees F and 104 degrees F.

D. Horsepower Rating: Suitable for connected load.

E. Voltage Rating: Suitable for circuit voltage.

F. Provide with switch blade contact position that is visible when the cover is open.

G. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
   1. Switches 600 Amps or smaller: Class R.

H. Conductor Terminations: Suitable for use with the conductors to be installed.

I. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.

J. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.

K. Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
      b. Outdoor Locations: Type 3R.
   2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.

L. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

M. Heavy Duty Switches:
   1. Comply with NEMA BS 31047.
   2. Conductor Terminations:
      a. Provide mechanical lugs unless otherwise indicated.
      b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.

N. Provide the following features and accessories where indicated or where required to complete installation:
   1. Auxiliary Switch: SPDT switch suitable for connection to system indicated, with auxiliary contact operation before switch blades open and after switch blades close.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive enclosed safety switches.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Provide required support and attachment in accordance with Section 26 05 29.

E. Install enclosed switches plumb.

F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.

G. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 60 inches above the floor or working platform.

H. Provide grounding and bonding in accordance with Section 26 05 26.

I. Provide fuses complying with Section 26 28 13 for fusible switches as indicated or as required by equipment manufacturer's recommendations.

J. Identify enclosed switches in accordance with Section 26 05 53.

K. Install fuses in fusible disconnect switches.

L. Bolt closed exterior grade level enclosures.

3.3 FIELD QUALITY CONTROL

A. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.4 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.5 CLEANING

A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION