

**COLORADO STATE UNIVERSITY - PUEBLO – ADMIN 111 DATA CENTER COOLING
UPGRADE**

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MEP SPECIFICATIONS**

Job No. 7693

July 30, 2018

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DOCUMENT 000107 - SEALS PAGE

1.1 DESIGN PROFESSIONALS OF RECORD

- A. Mechanical and Plumbing Engineer: Steven M. Taylor.



- B. Electrical Engineer: John M. Montano.



END OF DOCUMENT 000107

SECTION 22 1316

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions and Special Provisions.
- B. Furnish and install all concrete, grout, and other required materials to fill all blockouts and/or sleeves left open for this Contractor's convenience or for the installation of this work.

1.2 SCOPE

- A. Plumbing equipment drains.

PART 2 - PRODUCTS

2.1 FITTINGS

- A. Fittings for copper piping system shall be solder type drainage pattern conforming to ANSI B16.22 and B16.23.

2.2 JOINTS

- A. Joints for copper shall be soldered using 95-5 composition tin-antimony solder with non-corrosive flux.

2.3 PLUMBING EQUIPMENT DRAINS

- A. Equipment drain lines shall be Type M copper tubing with wrought solder fittings. Provide a dielectric union at all connections between ferrous to copper materials.

2.4 TRAPS AND TAILPIECES

- A. Unless otherwise specified, traps shall be copper-alloy adjustable tube type with slip joint inlet and swivel, not less than 20 gauge and without cleanout. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level and swivel joints below the discharge level, metal to metal or metal to plastic type as required for the application. Outlet shall be threaded or socket for solder joint connection as required by the application. Tailpiece shall be copper-alloy to match P-trap. Furnish cast brass wall escutcheon at waste penetration through walls.

2.5 CLEANOUTS

- A. Cleanouts shall be as manufactured by Zurn, Jay R. Smith, Watts, Wade, or Josam, and shall be of the same size as the pipe, except that cleanout plugs larger than 4 inches will not be required. Cleanouts installed in connection with cast iron soil pipe shall consist of a long sweep,

quarter-bend or one or two eighth bends extended to an easily accessible place, or as indicated on the drawings. A standard cleanout fitting, Zurn No. ZN-1400-ZB, with polished bronze top shall be caulked into the hub of the fitting and finished flush with the floor. Where cleanouts in connection with threaded pipe are shown and are accessible, they shall be cast iron drainage T-pattern, 90 degree branch fittings with square head brass screw plugs of the same size as the pipe up to and including 4 inches. Wall cleanouts in finished areas shall be Zurn No. Z-1460-8 with polished stainless steel or chrome plated metal cover.

- B. Install cover flush with grade (outside) to avoid tripping hazard.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All soil, waste, and vent piping shall be properly graded and installed in strict accordance with all applicable codes and requirements.
- B. Make all changes in direction of drainage piping by use of 45 degree wyes, long turn tee wyes, long sweep quarter bends, sixth, eighth or sixteenth bends. Short turn sanitary tees permissible on horizontal to vertical where space conditions require.

3.2 DRAINS

- A. The Contractor shall extend drain lines from all equipment requiring drainage, relief valves, and drain pans to the nearest floor drain or floor sink, and shall terminate indirectly with a minimum clearance of one (1) inch or as otherwise required by applicable codes and standards. Relief valve drain lines shall be extended to the nearest floor drain and shall be equal in size to relief valve outlet port.

END OF SECTION 22 1316

SECTION 23 0500

COMMON WORK REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. See General Conditions and Supplemental General Conditions.
- B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this Section and all subsequent sections of this Division and form a part of the contract.

1.2 INDEX OF SPEC SECTIONS FOR THIS DIVISION

23 0500	Common Work Requirements for HVAC
23 0501	Demolition
23 0504	Pipe and Pipe Fittings
23 0505	Piping Specialties
23 0523	Valves
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23 0549	HVAC and Electrical Installation Coordination
23 0550	Variable Frequency Drives
23 0593	Testing, Adjusting and Balancing of Mechanical Systems
23 0700	Mechanical Systems Insulation
23 0900	Facility Management System for DDC Controls
23 2113	Heating Hot Water System and Equipment
23 2123	Pumps
23 2313	Refrigerant Piping System and Equipment
23 3000	Air Tempering System and Equipment

1.3 DEFINITIONS

- A. General: Terms will have meanings as defined in Webster's Eleventh New Collegiate Dictionary except as noted below.
- B. Entities
 - 1. Owner: Colorado State University - Pueblo
 - 2. Architect: CSNA
 - 3. Engineer: Bridgers & Paxton
 - 4. Owner's Representative: The Owner will designate his representative after bid. The abbreviation "OR" may be used throughout these specifications to refer to the Owner's Representative.
 - 5. Owner's Agents: The Architect, Engineer, and others authorized to act on behalf of the Owner.

C. Actions

1. Supply: Procure and deliver to the site with all features as specified, required per code, and as required for proper installation. Include submittals, O&M manuals, operator instructions, and warranty.
2. Install: Set in place in accordance with manufacturer's instructions, contract documents, and applicable codes and standards. Coordinate the installation with other disciplines, start, and demonstrate proper operation.
3. Furnish: Supply and install.
4. Provide: Supply and install.
5. Accepted: By the Owner's Representative except as noted.
6. Approved: By the Owner's Representative except as noted.
7. Review: By the Engineer except as noted.

D. Locations

1. Buried: Surrounded by soil or other material, either beneath the building or exterior to the building.
2. Exterior: Exposed to rain or snow. Examples include rooftop locations, spaces around cooling towers, pipe racks, etc.
3. Interior: Not exterior or buried. Examples include not only spaces within the heated envelope of the building, but also unheated attics, covered loading docks in which spaces are protected from rain and snow, utility tunnels, sheds, etc.
4. Finished Spaces: Interior spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated attics, spaces above ceilings, crawlspace, and tunnels.
5. Exposed: Exposed to view. Examples include finished spaces mechanical equipment rooms, rooftops, etc.
6. Concealed: Not Exposed.

E. Other Definitions:

1. 24/7: 24 Hr/day, 7 days per week, year-round.
2. AHJ: Authorities having jurisdiction. The authorities having jurisdiction over this project are established by statute, and include governmentally designated building departments, the fire marshal, fire departments, etc. No attempt is made to list all such entities here; a qualified Contractor is expected to know and coordinate with the various authorities having jurisdiction.
3. FMS: Facility Management System
4. Local: Based no further from the job site than the Engineer is. For example, where the specifications call for a local factory authorized service agent, then on a daily basis that agent must be based in an office or warehouse located no further from the project site than the Engineer's office.
5. OAE: Or approved equal.

1.4 CODES AND PERMITS

- A. Perform all work in accordance with the 2015 International Building Code, the 2015 International Plumbing Code, and the 2015 International Mechanical Code, as adopted and

interpreted by the State of Colorado and City of Pueblo, and the National Fire Protection Association (NFPA Regulations), current adopted edition. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. Contractor shall hold and save the Owner and his agents free and harmless from liability of any nature or kind arising from the Contractor's failure to comply with codes and ordinances.

- B. Secure and pay for all permits necessary for performance of the work, including utility connections, extensions, meter pits and meter sets and tap fees for water, storm sewer, sanitary sewer and natural gas, unless otherwise specified herein.
- C. Comply with the requirements of, and the recommendations of:
 - 1. Applicable county and state mechanical, electrical, gas, plumbing, health and sanitary codes, laws and ordinances
 - 2. National Electrical Manufacturer's Association
 - 3. National Electrical Code
 - 4. Underwriters Laboratories
 - 5. American National Standards Institute
 - 6. American Society for Testing Materials
 - 7. Local utility companies
 - 8. National Fire Protection Association
 - 9. ASME Boiler and Pressure Vessel Codes
 - 10. Occupational Safety and Health Administration
 - 11. International Fire Code
 - 12. Midwest Insulation Contractors' Association (MICA)
 - 13. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
 - 14. American Society of Sanitary Engineering
 - 15. American Gas Association

1.5 PRIOR APPROVAL

- A. Equipment manufacturers and service providers are listed within the specifications for the work specified in this division. For the items listed below, the specified manufacturers and providers are the only ones presently approved, and may be the only ones allowed:

Air Handling Units and Air Conditioning Units

- B. Manufacturers and service providers who are not listed in these specs, and who offer equivalent or superior products or services, are invited to submit for approval prior to bid (prior approval). Submit two copies. Requests for prior approval must:
 - 1. Include the substitution request form at the end of this spec section.
 - 2. Include technical data sufficient for the Engineer to generally assess appropriateness for this project.
 - 3. Be submitted minimum ten days prior to the bid date in effect at the time of submission.
 - 4. Comply with any additional requirements per specification Division 1.

- C. Any additional prior approved alternate manufacturers and service providers will be published in an addendum prior to bid. Prior approval indicates that based on the information submitted it appears to the Engineer that the alternate might be capable of meeting the specifications and the design intent, and might be appropriate for the project. But prior approval does not guarantee this. Prior approved products and service providers must still go through the submittal process after award, and must still comply with the design intent and all specification requirements.
- D. Please do not request prior approval for products and service providers that are not listed above. Instead, for those items alternate manufacturers and alternate service providers may be submitted after bid in accordance with the submittal process, provided they meet or exceed the specifications and the indicated design intent.

1.6 DOCUMENT MANAGEMENT

- A. Contractor is encouraged to use a web-based document management system for RFIs and submittals. If used, Contractor shall provide and pay for licenses and training for the engineer's project personnel. The section below describes procedures for handling submittals if a web-based document management system is not used. If a web-based system is used, the procedures below shall be modified as appropriate.

1.7 SUBMITTALS

- A. Prior to purchasing materials, equipment and services, submit descriptive literature for review.
- B. See individual specification sections within this division for additional submission requirements. The following describes general submittal procedures. More specific procedures will be established after award. Whenever electronic files are to be submitted, e-mail them through normal channels. But if files are too large to e-mail, then submit them in quantities as described below.
 - 1. Submittal Schedule: Along with the first item submitted for review, include a schedule listing all items to be submitted and an approximate date for each submittal. Submit this schedule in both hard copy and electronic form (Microsoft Excel). Normal review time will be 10 working days or as indicated in Division 1. Schedule should identify any submittals for which expedited review is requested. Update this schedule and resubmit it monthly (by e-mail) for information.
 - 2. Include the following information with each submittal:
 - a. Cover sheet identifying the project name, contractor, architect, engineer, and items included. Indicate symbol numbers, spec section, etc.
 - b. A blank space large enough to accept a review stamp.
 - c. Performance under the specified conditions
 - d. Cover sheet shall clearly identify and **HIGHLIGHT** any ways in which the submitted materials, equipment or services deviate from the Specifications.
 - 3. Quantities:
 - a. Brochures: Submit no more than seven copies plus a PDF.
 - b. Drawings: Submit one reproducible, one print, plus a PDF.

4. Engineer will review one original submittal and one resubmittal for each item. If the Contractor fails to provide the required data or acceptable items with his second submittal, he will be charged for the Engineer's costs for the third and subsequent reviews.
 5. Required Information: Submit information to allow the Engineer to easily determine whether the submitted components comply with the general design intent. Include relevant descriptions of materials, features, performance, quality and dimensions. Cross out all features, options and accessories which will not be provided. It is assumed that all specified, indicated and/or required features will be provided unless specifically noted otherwise.
 6. Where specifications require a local factory authorized service agent, submit the name, address, and contact information for this agent. Include this information also in the O&M Manual.
- C. Review of Submittals: Engineer will review submittals for general conformance with the design intent.
1. Review of a separate item as such will not indicate review of the assembly in which the item functions.
 2. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work.
 3. Review will not relieve the Contractor of responsibility to comply with the contract requirements, or responsibility to ensure that equipment fits within the allotted space with required clearances for equipment operation, service and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC).
 4. For commodity type items (plumbing fixtures, terminal units, registers, diffusers, etc), Engineer will review submittals for type only. Contractor to coordinate sizes and quantities.
 5. Actions: Engineer will return submittals with one of the following actions:

NO EXCEPTIONS TAKEN	Contractor may proceed with the work as submitted
EXCEPTIONS AS NOTED	Contractor may proceed with the work and without resubmittal provided he complies with all exceptions noted in the submittal, and so states in a letter
REVISE AND RESUBMIT	Resubmit in accordance with the indicated comments
REJECTED	Resubmit in accordance with the contract documents
RETURNED WITHOUT ACTION	This submittal has not been reviewed, and therefore the Engineer is returning it with no direction to the Contractor.

D. Substitutions:

1. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or if any work is installed in a manner which is not in conformance with the requirements of this specification and for which the Contractor has not received written authorization, remove such unauthorized work and install work in accordance with the contract documents at no change in contract amount.
 2. Authorized Substitutions: Provide all accessories and features as required and coordinate substitutions with other disciplines. Bear any extra expenses resulting from the use of substitutions which affect adjoining or related work required in this division or other divisions of the work.
 3. If the Contractor substitutes equipment for that indicated on the drawings, he shall prepare a 1/4 inch = 1foot installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will properly fit within the space with adequate clearance for maintenance and replacement. Submit this drawing for review.
- E. Schedule: Submit all submittals in a timely manner consistent with the requirements for completing the work covered by this contract within the prescribed contract time. Be aware that there is risk in ordering components, fabricating work, and/or installing work prior to review. If the Contractor proceeds prior to review, and then the review comments required modifications to work which has begun or has been completed, then Contractor must comply with the review comments at no change in contract amount or schedule.
- F. Shop Drawings
1. Submit shop drawings for
 - a. Mechanical equipment rooms and other spaces housing air handling equipment, heat transfer equipment, fluid handling equipment, machinery, etc.
 - b. Complete supply, return, and exhaust ductwork systems, both exposed and concealed.
 - c. Piping for HVAC, plumbing, both exposed and concealed.
 2. Show the location and elevation of all equipment, ductwork and piping, as well as openings through slabs and walls. Include plans, elevations and sections as appropriate. Clearly show the manner in which the systems fit into the available space and relate to each other and to the building elements. Indicate required sleeves and openings in general construction elements. Indicate required clearances for operation, maintenance and replacement of operating devices and equipment. Drawings shall be of appropriate scale to facilitate coordination and understanding, but not smaller than 1/4 inch scale for floor plans and 1/4 inch scale for equipment rooms and chases.
 3. Conflicts: The engineer has endeavored to work out conflicts in areas where the design is congested, but has not tried to show all required offsets to coordinate with the building construction and building systems, particularly in less congested areas. The intent is that the Contractor coordinate the design of the piping and ductwork distribution systems with the building construction and the various building systems, particularly in less congested areas. Provide experienced designers to perform such services and prepare shop drawings. Exercise good design practice in working out conflicts without compromising

system operation or maintenance. Provide fittings, offsets, etc., as required. Contractor shall include this design effort and include the labor and materials for such fittings and offsets in his base bid. Except in extremely unusual circumstances, no additional costs will be allowed related to working out conflicts. Coordinate with other disciplines as required. Identify on the shop drawings those areas where redesign was necessary to resolve design conflicts.

- a. In the event that the Contractor desires direction in resolving a design conflict or desires prior approval of a recommended approach to resolving a conflict, submit an RFI which identifies the conflict and suggests a recommended solution.
- b. In resolving conflicts, gravity lines and larger distribution mains will generally have priority over pressurized lines and smaller lines as follows:

Plumbing waste and vent lines
 Roof drains
 Steam and condensate piping
 Supply, return and exhaust ductwork
 Fire sprinkler mains
 Heating hot water and chilled water piping
 Domestic hot and cold water
 Fire sprinkler branch piping and sprinkler runouts
 Pneumatic control piping
 Miscellaneous special piping systems

4. Use of Engineer's CADD Database or BIM Model: The Engineer will provide the Contractor electronic files of the Engineer's CADD Database or BIM Model of the design documents if the Contractor completes and submits the License Agreement form included at the end of this spec section. These files show the general design intent and may be used as a starting point for the Contractor to begin his shop drawings and coordination effort, but the Contractor should not use them as a basis for ordering or fabrication. The normal submittal process still applies, regardless whether the Contractor elects to use the Engineer's CADD Database or BIM Model.

G. Submittals Required under this Specification Section:

1. Electrical Components: Motors, Motor Controllers, and Variable Speed Drives
2. Identification: Products used to identify equipment, ductwork, valves, piping, and control devices.
3. General Construction Components: Roof Curbs & Access doors.

1.8 MISCELLANEOUS PROVISIONS

A. Qualifications

1. All mechanics shall be skilled in their respective trade.
2. All welders shall be certified in accordance with the ASME Boiler Test Code, Section IX, latest issue.

B. Regulated Materials: Comply with all state, local and federal regulations regarding the storage,

handling or disposal of oils, lubricants, cleaning agents, refrigerants, other liquids and gases, and hazardous materials.

- C. **Factory Identification:** Provide all materials and equipment with labels sufficient to show compliance with these specifications and the performance requirements indicated on the drawings. All equipment shall carry a permanent label installed by the manufacturer stating that the equipment complies with ASHRAE/IESNA Std. 90.1.
- D. **Hazardous Conditions:** Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.
- E. **Hazard Signs**
 - 1. Provide a sign reading, "Hazardous Area - Authorized Personnel Only" on the doors to all equipment rooms, fan plenums, and similar areas containing moving or rotating parts, or other potentially hazardous environments.
 - 2. Provide a sign reading, "Confined Space - Entry by authorized personnel only by permit" for all confined spaces. Confined spaces shall be as designated by OSHA Standard 1910.146. This generally means a space that:
 - a. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
 - b. Has limited or restricted means for entry or exit (for example, tanks, vessels, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
 - c. Is not designed for continuous employee occupancy.
 - 3. Survey the final premises to determine where any potentially hazardous areas exist. If the Contractor feels that hazards exist which cannot be suitably provided for through the above typical methods, he shall forward in writing his concerns, and request for a decision concerning the referenced hazard, prior to the final inspection of the facilities.

1.9 GUARANTEE-WARRANTY

- A. The following warranty shall be binding:

"The Contractor warrants that this installation is free from mechanical defects. Contractor agrees to replace or repair any part of the installation which may fail within a period of one year after the date established below, provided that such failure is due to defects in materials or workmanship, or to failure to follow the specifications and drawings. This warranty shall begin on the date set forth in the Certificate of Substantial Completion, AIA Form G704, or other such date as documented in writing by the Owner's Representative."

- B. The extent of guarantees or warranties by equipment and/or materials manufacturers will not diminish the requirements of the Contractor's warranty to the Owner.

PART 2 - PRODUCTS

Administration 111 Data Center Cooling Upgrade
Colorado State University-Pueblo

2.1 PRODUCT GENERAL REQUIREMENTS

- A. General: Products supplied under Division 23 shall comply with the following except as noted elsewhere.
- B. Products shall be new; shall be the product of manufacturers regularly engaged in the production of plumbing, heating, ventilating, air conditioning, and control system equipment; and shall be the manufacturer's latest design. Specs and equipment schedules establish expectations regarding standard of quality and operating intent.
- C. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.
- D. Products shall be suitable for the conditions under which they are installed and operated. Prior to or during the submittal phase advise the Owner's representative and the Engineer in writing regarding any concerns about the suitability of the specified products for the intended application or service. Request clarification if any question exists regarding the design intent.
- E. Performance Ratings: Unless otherwise noted, all scheduled equipment performance is based on an elevation of 4721 feet above sea level. Adjust manufacturer's ratings accordingly.
- F. Structural Soundness: Products shall have structural integrity appropriate to the component and its application. Bases shall be rigid and shall keep all components in proper alignment. Structural integrity shall be adequate for both rigging and final installation. Components shall not be loose, rattle, or vibrate unnecessarily in their final installed condition.
- G. Corrosion Resistance: Equipment shall be of materials inherently corrosion resistant, or shall be finished with a corrosion-resistant finish suitable for the location in which the equipment is installed.
- H. Touch-up: If the factory finish of any component is damaged prior to substantial completion, touch up to original condition per manufacturer's recommendations.
- I. Equipment Access Doors or Panels: Provide access doors and panels within equipment to ensure good access to all components requiring inspection, service or maintenance. Provide appropriate hardware. Equipment installed outdoors shall be weather-tight.
- J. Fans: Statically and dynamically balanced, shaft first critical speed shall be above operating speed at design conditions.
- K. Bearings: Grease lubricated or permanently lubricated.
- L. V-Belt Drives: All components sized for 150% of motor HP, multiple belts shall be matched, fixed sheaves for motors 20 Hp and larger, adjustable sheaves for lower HP motors, all safety components for OSHA compliance (e.g., belt guard or other safety provisions) motor mounted on adjustable base. Provide a replacement sheave for each fixed sheave after T&B is complete. Include belt data in O&M manual. Gates Rubber Co, OAE.

1. Belt Guards: Rigidly constructed and attached, removable, galvanized steel, expanded mesh. Design to provide ready access to bearings.
- M. Couplings: Provide coupling guard.
- N. Motors and VFDs: See requirements described elsewhere in this spec section.
- O. Drive Lines (starter or VFD, motor, coupling and shaft or v-belt drive and pulleys, and driven equipment): Coordinate with all suppliers and ensure all components are compatible to work as a system.
- P. Coils: ARI rated, copper tubes mechanically expanded into aluminum fins, galvanized steel casing, drainable, pressure tested to 150% of working pressure but not less than 300 psi.
- Q. Cooling Coil Drain Pans: Provide for all cooling coils, galvanized or stainless steel, double pitched with piped outlet. For units with more than one coil stacked, provide intermediate drain pans piped to the main drain pan.
- R. Gas Burners: Natural gas fired, performance based on gas at 1000 Btu/SCF HHV but suitable for use with gas at 900 – 1050 Btu/SCF and 7 – 11 inches water column, factory installed and pressure tested gas train, all necessary safety and operating controls.
- S. Filter Frames: Galvanized steel, provide wherever filters are specified.
- T. Roof Curbs and Support Rails for Roof-Mounted Equipment: Roof curbs should generally be supplied with the equipment which the curb supports, and shall comply with the requirements of the National Roofing Contractors' Association. Match curb to the requirements of the supported equipment. The roof pitch is indicated on the architectural drawings. If roof pitch exceeds the recommendations of the equipment manufacturer, provide a curb that will level the equipment. Factory fabricated, minimum 12-inch, structurally adequate for the load supported, not less than welded 18-gauge (16-gauge or heavier for sizes more than 50-inches) galvanized steel with minimum 1-inch fiberglass insulation, 2 x 2 wood nailer, and with cant and step if required to match specified roof. Provide damper tray for un-ducted fan applications. Ship small curbs fully assembled; large curbs may be knocked down for shipment.
- U. Electrical & Controls: Except where specifically noted, electric service to each component listed on the equipment schedules will be through a single electrical feed at the voltage indicated on the equipment schedules. Include all components, cabling and conduits to distribute power to all components which are factory supplied and mounted. Provide transformer(s) if required to serve unit-mounted components requiring electric service at voltages different from the main electric service, including controls components. Provide secondary overcurrent protection. Provide terminal strips for field-installed control wiring. Provide unit-mounted, unit-specific wiring diagrams on durable paper, attached to inside of control panel door or otherwise affixed to the unit. All electrical components shall be UL Listed or Recognized. All factory-installed electrical work shall comply with the NEC unless the overall unit is listed by an organization acceptable to the AHJ, and listed to a standard acceptable to the AHJ.
1. Where equipment includes an LCD or other, similar display for operator interface,

- display all information in English. Displays should be readily understandable and should not require the user to look up display codes in a reference manual.
2. Provide battery backup to retain all memory and programming, and to keep all clock-related functions powered through a 1-week power outage.
 3. Controls interface with the FMS:
 - a. Digital Inputs to FMS: 24V DC sourced from equipment.
 - b. Digital Outputs from FMS: Equipment to have form C relays, max 250V DC, 2 A.
 - c. Analog Inputs to FMS: 4-20 mA, 0-5V DC, or 0-10V DC sourced from equipment.
 - d. Analog Outputs from FMS: 4-20 mA sourced from FMS.

2.2 ELECTRICAL COMPONENTS

- A. General: Except as noted, all electrical products and equipment shall comply with the requirements of this section, whether field installed or factory installed. See “Product General Requirements” and “Installation General Requirements” in Parts 2 & 3 of this spec section for additional requirements.
- B. Motors
 1. General: Except as noted motors shall be horizontal, open drip-proof, 4-pole, 1750 RPM, rated per NEMA MG-1, with fabricated steel or cast iron casing, motor terminal box adequately sized for conductors one-size larger than specified, SS nameplate per NEMA MG-1-20.60, connection diagram attached to motor, compression lugs for power feeds and ground conductor, grease lubricated sealed ball bearings or roller bearings with standard grease fitting zerk and relief tapping, factory lubricated, dynamically balanced to no more than 50% of the NEMA allowable vibration limits. For motors powering V-belt drives, provide a cast iron or steel base with slide rail and adjustable belt tension device. Install motors and equipment on foundations and align as required. 40 deg C rise and total temperature rise of 65 deg C ambient.
 - a. 3/4 hp and smaller: 115V, single phase, 60 Hz, split phase or permanent split capacitor (PSC), NEMA Type N or O, with built-in thermal overload protection.
 - 1) Multi-speed motors.
 - b. 1 hp and greater: 460 V, 3 phase, 60 Hz, squirrel cage induction type, NEMA design B, T-frame, with Class B or F insulation, lifting lugs, 150,000 hr L-10 bearings for direct-coupled applications, 50,000 hr L-10 bearings for belt-driven application with radial loads and pulley sizes per NEMA MG1-14.43. Service Factor: ODP motors shall be rated for 1.15 SF at 40°C or 1.0 SF at 65°C; TEFC motors shall be 1.0 SF.
 - 1) Two speed motors: Provide with two separate windings.
 - 2) Variable speed motors: Drive compatible per NEMA MG1-31, premium efficiency as specified below regardless of Hp, Class F insulation, minimum 5-year warranty.
 2. Efficiency: Except as noted, motors shall be premium efficiency type, with nominal efficiencies not less than the following as per the Consortium on Energy Efficiency (CEE), and minimum power factor of 0.85:

	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
HP	1200 RPM	1800 RPM	3600 RPM	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	80.0	82.5	85.5	78.5
1.5	86.5	86.5	85.5	87.5	86.5	85.5
2	87.5	86.5	86.5	88.5	86.5	86.5
3	89.5	89.5	86.5	89.5	89.5	88.5
5	89.5	89.5	89.5	89.5	89.5	89.5
7.5	91.7	91.0	89.5	91.7	91.7	91.0
10	91.7	91.7	90.2	91.7	91.7	91.7
15	92.4	93.0	91.0	92.4	92.4	91.7
20	92.4	93.0	92.4	92.4	93.0	92.4
25	93.0	93.6	93.0	93.0	93.6	93.0
30	93.6	94.1	93.0	93.6	93.6	93.0
40	94.1	94.1	93.6	94.1	94.1	93.6

3. Approved Manufacturers: General Electric Energy Saver, Baldor Super-E, Marathon Series E, Reliance Electric XE, Westinghouse TEE II, Eaton/Cutler Hammer, Toshiba, Louis Allis, or approved equal.
4. If the Contractor proposes to furnish motors varying in horsepower and/or characteristics from those specified, he shall first submit his request for the change and shall then coordinate the change with all other parties (e.g. electrical contractor) and pay any costs associated with the change.

C. Motor Controllers

1. Single Phase Manual Starters to 1 Hp and 120-277 V: Cutler Hammer MS with indicating light.
2. 3-Phase: Full voltage, non-reversing, electro-mechanical, combination circuit breaker and motor controller, UL Listed, NEMA rated, 460V, 65,000 AIC, minimum 50 VA 24V controls transformer with secondary overcurrent protection, suitable for operation at -4°F to +149°F and specified voltage -15% to + 10%, adjustable solid state overloads initially set at Class 10, HOA switch, run indicator, two auxiliary contacts for remote monitoring of status, and enclosure for surface mounting. Cutler Hammer OAE.
 - a. Provide enclosure appropriate to the location:
 - 1) NEMA-1 for indoor dry locations.
 - 2) NEMA-3R for outdoors.
 - 3) NEMA-4 for wet applications.
 - 4) NEMA-12 for dusty locations.
 - 5) Explosion-proof – where required.
 - b. Motor controllers factory mounted and wired on AC units, boilers, etc, may be definite purpose, and need not have all the features specified here.

2.3 ELECTRICAL WIRING AND CONTROL EQUIPMENT

- A. Provide wiring and conduit as scheduled in Section 23 0549.

- B. Coordinate with all disciplines to ensure that all necessary components of control work are included and fully understood.

2.4 IDENTIFICATION

- A. Scope: Identify all equipment, ductwork, valves, piping, and control devices shown on the Drawings, identified in the equipment schedules, and indicated in these Specifications. Provide submittals for products and procedures used for identification.
- B. Equipment: For all mechanical equipment supplied or installed under Division 23, provide an equipment identification tag or stencil unit number onto the equipment. Stencils shall be minimum 3-inch height, dark contrasting color, of a material suitable for the application.
 - 1. For rooftop HVAC equipment, provide a permanently affixed, weather-resistant label to identify the areas served.
- C. Valves: Provide each valve with a stamped metal tag secured to the valve. Tag shall indicate the valve number, service and function. Provide two sets of prints of drawings showing floor plan for each floor with all valves accurately located and labeled. Drawings shall be neat and easily readable. Provide a typed valve chart, listing the valve number, size, location, function, normal operating position, for each valve. List valves by system, i.e., domestic cold water, hot water, chilled water, etc. Tags shall be stamped brass 1-1/2" diameter, and secured to valves by heavy copper figure eight hooks, braided stainless steel wire anchor, or other approved means.
- D. Ductwork: Identify ductwork at or near the fan with stenciled signs on insulated ductwork or engraved laminated plastic signs secured by rustproof screws on un-insulated ductwork. Sign shall identify air conditioning system or fan unit and area served.
- E. Piping
 - 1. Provide color-coded pipe labels indicating the service of the pipe and the direction of flow. Piping labels shall comply with ANSI Standard A13.1 regarding color coding and size of lettering. The following standardized color code scheme shall be used:
 - a. Yellow - Hazardous Materials.
 - b. Green - Liquid Materials of Inherently Low Hazard.
 - c. Blue - Gaseous Materials of Inherently Low Hazard.
 - d. Red - Fire Protection Materials.
 - 2. Labels shall be semi-rigid plastic identification markers. Labels shall "span-on" around pipe without the requirement for adhesive or bonding of piping sizes 3/4 inch through 5 inches. Labels for piping 6 inches and larger shall be furnished with [spring attachment](#) at each end of label. "SETMARK" Type SNA, 3/4 inch through 5 inch size and Type STR, 6 inches and larger, as manufactured by Seton Name Plate Corporation, Brady, or equivalent.
 - 3. Labels shall be vinyl material with permanent adhesive for application to clear dry pipe and/or insulation jacketing. Pressure sensitive pipe tape matching the background color of the label shall be placed over each end of the label and completely around the pipe.
 - 4. For retrofit projects the system names shall match existing.
 - 5. Attach pipe markers to lower quarter of the pipe on overhead horizontal runs and on the

centerline of vertical piping where view is not obstructed.

6. Provide the following labels, with ANSI/OSHA color and banding for all piping systems as shown on the Drawings and as listed below:

<u>Service/Legend</u>	<u>Letter Color</u>	<u>Background Color</u>	<u>Tape Banding Color</u>
Domestic Cold Water	White	Green	2" Green
Domestic Hot Water	Black	Yellow	2" Yellow
Domestic Hot Water Return	Black	Yellow	2" Yellow
Roof Drain	White	Green	2" Green
Sanitary Sewer	White	Green	2" Green
Storm Sewer	White	Green	2" Green
Natural Gas	Black	Yellow	2" Black
Condensate Drain	Black	Yellow	2" Black
Heating Water Supply	Black	Yellow	2" Yellow
Heating Water Return	Black	Yellow	2" Yellow
Refrigerant	White	Green	2" Green

7. Locations: Label pipes at the following points on each piping system:

- Adjacent to each valve in piping system.
- At every point of entry and exit where piping passes through a wall.
- On each pipe riser and junction.
- At a maximum interval of 20 feet on pipe lines exposed and concealed above accessible ceilings.
- Adjacent to all special fittings (regulating valves, etc.) in piping systems.
- At every access door.

- F. Control System Devices: All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the Contract Drawings.

2.5 GENERAL CONSTRUCTION COMPONENTS

A. Roof Curbs and Equipment Support Rails

- General: Factory fabricated, minimum 12-inch high, galvanized steel, configured to account for roof pitch where pitch exceeds 1/4-inch/ft or where required by manufacturer of supported equipment. Coordinate with roofer and provide cant and step if needed to match roof construction.
- Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, RPS, OAE.
- Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck, RPS, OAE.

B. Access Doors (ADs)

1. Steel frame and door, surface mounted, factory primed, 150° opening, flush, screw-driver operated cam lock, minimum 24" x 24" except as approved, but larger where required for proper access. Where ADs are installed in general construction with a pattern, match AD dimensions to this pattern. Milcor, Krueger, OAE.
 - a. Sheet Rock Wall or Ceiling: With drywall bead on frame, Milcor Style DW.
 - b. Plaster Wall or Ceiling: Milcor Style K.
 - c. Masonry Walls: Milcor Style M.
 - d. 1-hr and 2-hr rated walls: UL Listed for 1.5-hr Class B Fire Rating, self-closing and self-latching. Milcor Style UFR.
 - e. Suspended Ceilings: Milcor Style AT.
 - f. Fire Rated Suspended Ceilings: Milcor Style ATR.

- C. Painting: Finish painting of mechanical systems and equipment will be under Spec Section 09 9100, "Painting," unless equipment is specified to be provided with factory-applied finish coats.

2.6 MISCELLANEOUS PROVISIONS

- A. Flow Diagrams: Provide half-size prints of each system flow diagram, including air handling, steam, chilled water, heating water, domestic water, domestic HW, etc. Mount framed under plexiglass, and locate either on the associated AHU or on a nearby wall. Incorporate any as-built revisions.

PART 3 - EXECUTION**3.1 INSTALLATION GENERAL REQUIRMENTS**

- A. Cooperation with Other Trades: Refer to other parts of these Specifications covering the work of other trades which must be carried on in conjunction with the mechanical work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. Be responsible for the size and location of all openings, foundations, etc.
- B. Trenching and Backfilling: Provide all excavation, trenching and backfilling required for the installation of the work of this division.
- C. Manufacturer's Instructions: Install all products in accordance with manufacturers' recommendations and the requirements of any applicable listings. If manufacturers' recommendations and/or requirements of applicable listings conflict with plans and specifications, report such conflicts to the Owner's Representative.
- D. Field Measurements: Verify all dimensions and conditions governing the work. Examine adjoining work on which the work of this Division is dependent, and report any deficiencies.
- E. Do not compromise the building structural, fire resistant construction or vapor barrier system.

- F. Supports for Equipment and Systems: Foundations and structural supports for equipment will generally be provided by others. The contractor for this division shall provide supplementary supports as required to support equipment, distribution systems, and other components installed under this division. Prior to installing mechanical work, examine foundations and supports to ensure they are adequate to properly support the equipment. Provide all necessary foundations, structures, supports, inserts, sleeves, etc, for installation of mechanical and plumbing equipment, ductwork and piping, etc. Coordinate installation of such devices with all disciplines. Verify that the devices and supports are adequate as intended and do not overload the building structure.
- G. Concealed or Buried Work: For work which is underground or which will be concealed by building construction, provide digital photographs to document the installation throughout the construction project, but not less than weekly. Include plans indicating where the photographs were taken. Notify the OR of when the work will be complete and provide OR a minimum five-day period to inspect the work after completion but prior to when it is backfilled or concealed by building construction.
- H. Access Doors: Provide as required for access to valves, dampers, controls, or other items for which access is required for either operation or servicing. The type of access door shall be as required by the room finish schedule.
- I. Alignment of Flexible Couplings: Flexible couplings between motors and driven equipment shall be aligned by a qualified service technician after the equipment is installed and ready for operation. Align equipment per manufacturer's recommendations under operating conditions and temperature. Provide written certification that each device has been so aligned.
- J. Lubrication: Provide all oil for the operation of all equipment until acceptance. Be responsible for all damage to bearings while the equipment is being operated by Contractor up to the date of acceptance of the equipment. Protect all bearings and shafts during installation and thoroughly grease shafts to prevent corrosion. Bearings for items of mechanical equipment shall be marked at each bearing location as to whether the bearing is a sealed type or relubricable type unit.
- K. Tests: All tests shall be conducted in the presence of the designated and authorized Owner's Representative. Notify the Owner's one week in advance of all tests. Requirements for testing are specified under the sections covering the various systems. Provide all necessary equipment, materials, and labor to perform the required tests.
- L. Protection of Material and Equipment:
 - 1. Protect all work, materials and equipment furnished and installed under Division 23, whether incorporated in the building or not.
 - 2. All items of mechanical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner as approved.
 - 3. Protect all work and be responsible for all damage done to property, equipment and materials. Coordinate material storage with the Owner's Representative.
 - 4. Pipe and duct openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. Plumbing fixtures shall not be used by the construction forces. At the completion of the work clean and polish fixtures,

equipment and materials prior to turning them over to the Owner.

3.2 DRAWINGS

- A. The drawings show the general arrangement of the piping, ductwork, equipment, etc. Follow them as closely as actual building construction and work of other trades will permit. Where discrepancies occur between Plans and Specifications, the more stringent shall govern. All Contract Documents shall be considered as part of the work. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories, which may be required, and no attempt has been made to do so. Rather, the drawings convey the general design intent. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing fittings, valves, and accessories as required to meet such conditions. Show any such changes on the Record Drawings.
- B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, submit an RFI.
- C. Install equipment, piping, ductwork, and electrical systems with proper clearance for operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions, etc. Include proper clearance in front of and above electrical equipment as defined by the National Electric Code (NEC). Piping and ductwork systems shall not be routed through or above electrical equipment rooms, telecommunications rooms, elevator machine rooms, or electrical equipment spaces within mechanical equipment rooms.
- D. Arrange all concealed mechanical systems carefully to fit within the available space without interference with adjacent structural and electrical systems. Make all necessary provisions for penetrations of piping and ductwork, including sleeves and blockouts in structural systems. The exact location of all exposed mechanical systems, including grilles, registers, and diffusers; access doors; sprinkler heads; piping and ductwork exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it relates to the aesthetic design for the facility.

3.3 EQUIPMENT SUPPLIED BY OTHERS

- A. **[Certain items of mechanical equipment as listed on the Drawings and/or Specifications will be furnished [under other sections of this Specification for mechanical rough-in and connection under Division 23, including plumbing, domestic water and waste, process cooling water, compressed air, exhaust, etc.]. All required mechanical services, including connection of such services to equipment shall be provided under Division 23.]**

3.4 INTERRUPTING SERVICES

- A. Coordinate the installation of all work within the building in order to minimize interference with the operation of existing building mechanical, plumbing, fire protection, and utility systems during construction. Connections to existing systems requiring the interruption of service within the building shall be carefully coordinated with the Owner to minimize system downtimes. Requests for the interruption of existing services shall be submitted in writing a minimum of two weeks before the scheduled date. Absolutely no interruption of the existing

services will be permitted without written review and authorization.

3.5 CONCRETE BASES AND HOUSEKEEPING PADS

- A. Concrete bases and housekeeping pads shall be installed under all pieces of mechanical equipment unless specifically deleted by the Specifications or Drawings.
- B. Be responsible for the accurate dimensions of all pads and bases and furnish and install all vibration isolators, anchor bolts, etc.
- C. Provide concrete housekeeping pad foundations for all floor mounted equipment installed under this section unless otherwise shown on the Drawings. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these Specifications. Pad foundations shall be 4 inches high minimum, unless otherwise indicated on the Drawings. Chamfer edges shall be 1 inch. Faces shall be free of voids and rubbed smooth with carborundum block after stripping forms. Tops shall be level. Provide dowel rods in floor for lateral stability and anchorage.
- D. Equipment anchor bolts shall be set in a galvanized pipe or sheet metal sleeves 1 inch larger than bolt diameter. Anchor bolts shall be high strength steel J-shape. Anchor bolt design shall be arranged and paid for by the Contractor.
- E. Machinery bases, bed plates, sole plates, or vibration isolation units shall be carefully aligned, shimmed, leveled, and then grouted in place with commercial non-shrink grout. When a flexible coupling is employed as a part of the drive train, the coupling shall be aligned before the machinery base is grouted.

3.6 PRESSURE RELIEF DEVICES

- A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.
- B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

3.7 INSTALLATION CHECK

- A. An experienced, competent, and authorized representative of the equipment listed below shall visit the site of the work and inspect, check, adjust if necessary, and approve the installation for the equipment listed below. The equipment supplier's representative shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation is approved and accepted.
- B. Each equipment supplier's representative shall furnish a written report certifying that the equipment (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from any undue stress imposed by connecting piping or anchor bolts; and, (4) has been operated

under full load conditions and that it has operated satisfactorily.

- C. Equipment requiring installation check includes the following:

Chillers
Air Handling Units
Facility Management System (See Specification Section 23 0900)

3.8 OPERATION PRIOR TO ACCEPTANCE

- A. Operation of equipment and systems for the benefit of the Owner prior to substantial completion will be allowed provided that a written agreement between the Owner and the Contractor has established warranty and other responsibilities to the satisfaction of both parties.
- B. Operation of equipment and systems for the benefit of the Contractor, except for the purposes of testing and balancing, will not be permitted without a written agreement between the Owner and the Contractor establishing warranty and other responsibilities.

3.9 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

- A. At completion of the project provide two complete bound sets of the following documents, along with two CDs containing searchable PDFs of these documents. Organize bound information in a logical fashion with a table of contents and tabs for the different sections. Organize PDFs in a logical fashion with bookmarks to assist the operating personnel in retrieving desired data. Provide minimum two 1-hour sessions to instruct Owner's facility personnel in how to find information in the bound O&Ms and the PDFs. Take attendance and submit the attendance list to the Owner's Representative. Include the following:
1. Approved Submittals.
 2. Test reports.
 3. O&M manuals and instructions covering all equipment supplied under this Division, with all non-applicable information crossed out. Clearly identify all required routine maintenance. Include parts lists.
 4. A master Lubrication Chart listing each piece of equipment, the recommended oil or grease, and the recommended frequency of lubrication.
 5. The names and addresses of at least one service agency capable of providing required maintenance for each item of equipment supplied.
 6. Complete temperature control diagrams including control descriptions, system sequence of operation, operating instructions, control system maintenance and calibration information, wiring diagrams, and all control setpoints. See Section 23 0900 for additional requirements.
- B. See Division 1 for additional requirements concerning manuals, manual distribution, and maintenance materials.
- C. Submit O&M manuals for review and distribution to the Owner not less than two weeks prior to the date scheduled for O&M instructions as specified.
- D. Demonstrate proper system operation to the owner's operating staff. Provide the services of the

contractor and subcontractors (e.g., mechanical, T&B, temperature control, etc), as required to properly demonstrate system operation.

- E. Provide the necessary skilled labor and helpers to operate the mechanical systems and equipment for a period of **1 day** of eight hours. During this period, instruct the owner's facility staff fully in the operations, adjustment and maintenance of all equipment provided. Provide at least two weeks advanced notice, with a written schedule of each training session, the subject of the session, the Contractors' Representatives who plan to attend the session, and the time for each session. Take attendance and submit attendance sheets to the Owner's Representative.
- F. Film the instruction and training sessions submit two copies of the DVD.

3.10 RECORD DRAWINGS

- A. See Division 1, for additional requirements associated with Project Record Drawings.
- B. Maintain a full-size set of marked-up prints showing the installed location and arrangement of all work under this division, and in particular where changes were made during construction. Keep record drawings accurate and up-to-date throughout the construction period. Owner's Agents may request to review record drawings during construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFIs, bulletins, and change orders neatly taped or attached to record drawing set. At the completion of the project send the Engineer full-size plans clearly showing all changes from the original design marked up in red so as to facilitate the Engineer incorporating these changes into the Engineer's CADD files. Forward record drawings to the Owner's Representative prior to submitting a request for substantial completion.

3.11 SITE VISITS AND OBSERVATION OF CONSTRUCTION

- A. The Engineer may make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the work so as to determine if such work is proceeding in general accordance with the Contract Documents. This observation will not release the Contractor from his responsibility to supervise, direct, and control all construction work and activities. The Engineer has no authority over, or responsibility for means, methods, techniques, sequences, or procedures of construction or for safety precautions and programs, or for failure of the Contractor to comply with applicable laws, regulations, or codes.
- B. Prior to substantial completion, request that the Engineer provide a final observation visit. Complete the attached "Final Observation Checklist," and include it with this request. For any items that are not applicable, mark them "N/A."

3.12 PROJECT CLOSEOUT

- A. Submit written certification that all work complies with the specifications and applicable codes. Submit certifications and acceptance certificates including proof of delivery of record drawings, O&M manuals, spare parts required, and equipment warranties.

END OF SECTION 23 0500

Project: _____

Date Submitted: _____

General Contractor: _____

Date of Final Mechanical System: _____

Mechanical Contractor: _____

Observation Requested: _____

CONTRACTOR'S MECHANICAL & PLUMBING CHECK LIST
(ALL APPLICABLE ITEMS MUST BE COMPLETED PRIOR TO FINAL OBSERVATION)

In advance of requesting a final mechanical observation for installed mechanical systems, please check all items that have been completed. For all items not applicable to this project mark N/A.

PLUMBING/PIPING

- _____ 1. All plumbing fixtures are set, sealed and cleaned.
- _____ 2. All domestic and HVAC pipe systems are insulated.
- _____ 3. All pipe systems are identified with specified labels and directional arrows.
- _____ 4. Floor sinks and drain grates are cleaned and debris removed.
- _____ 5. Valve tags are installed.
- _____ 6. Special equipment (water softeners, water heaters, piping systems, etc.,) have been checked and put into service.
- _____ 7. Medical gas systems have been checked and certified.
- _____ 8. Special piping systems have been cleaned and pressure tested.

_____ Fuel Handling	_____ Process Piping
_____ Compressed Air	_____ Nitrogen
_____ Natural Gas	_____ Vacuum
_____ Other	_____ Argon
	_____ Medical Gas
	_____ Other
- _____ 9. Limestone chips have been installed in acid dilution sumps.
- _____ 10. Plumbing/piping connections have been completed to Owner-furnished equipment and equipment furnished by other Contractors/Subcontractors.
- _____ 11. Exterior wall hydrants have been cleaned.
- _____ 12. Concrete collars have been installed at clean-out to grade, valve box, or other specified plumbing items.
- _____ 13. Drains and relief lines from plumbing and HVAC equipment have been installed and secured in a proper manner.

- _____ 14. All plumbing equipment and areas of equipment have been cleaned and debris removed.
- _____ 15. All plumbing equipment required by the Specifications has been identified and/or numbered.
- _____ 16. Domestic water systems sterilization has been completed.
- _____ 17. Refrigerant piping/system has been charged and tested.
- _____ 18. Strainers/suction diffusers have been cleaned.
- _____ 19. Backflow preventers have been tested.
- _____ 20. Air has been vented from all coils and systems.
- _____ 21. Water treatment systems have been charged and tested.
- | | |
|---------------------|------------------------|
| _____ Chilled Water | _____ Condenser Water |
| _____ Hot Water | _____ Steam/Condensate |
- _____ 22. Ethylene glycol system has been charged with correct mixture and tested.
- _____ 23. Water systems have been cleaned (X) and pressure tested (P)
- | | |
|--------------------------------|----------------------------|
| _____ Chilled Water | _____ Condenser Water |
| _____ Hot Water | _____ Non-potable Water |
| _____ Steam | _____ Domestic Hot Water |
| _____ Condensate | _____ Domestic Cold Water |
| _____ Fire Protection | _____ Acid Waste and Vent |
| _____ Sanitary Sewer and Vent | _____ Heat Recovery Piping |
| _____ Roof and Overflow Drains | _____ Other (list) |
- _____ 24. PRVs have been adjusted (water, steam, gases).

FIRE PROTECTION

- _____ 1. Fire protection piping is completed.
- _____ 2. Fire protection system has been certified by the Fire Marshal's office.
- _____ 3. All electrical interlocks between the fire sprinkler components and the fire panel have been checked for operation.
- _____ 4. Spare sprinkler head, wrench and cabinet are installed.

HVAC - EQUIPMENT AND DUCTWORK

- _____ 1. All ductwork has been sealed and insulated.
- _____ 2. Return air paths and transfer openings have been verified.

- _____ 3. Air handlers have been cleaned inside and out and construction filters removed and replaced with final filters.
- _____ 4. All air handling equipment has been started and operated for the specified time.
- _____ 5. All equipment isolators have been adjusted for specified deflection.
- _____ 6. All VAV boxes, fan coils, or fan powered boxes are completed and operational.
- _____ 7. All pump shafts and couplings have been aligned.
- _____ 8. Ductwork, coils, housing, diffusers, registers and grilles have been cleaned.
- _____ 9. Boilers have been fired and certified by the supplier.
- _____ 10. Cooling towers have been started and inspected by the supplier.
- _____ 11. Chillers have been charged, started and certified for operation by the supplier.
- _____ 12. Fire dampers are accessible and fully operational.
- _____ 13. All HVAC equipment has been lubricated.
- _____ 14. HVAC equipment has been labeled in accordance with the Specifications.
- _____ 15. Duct pressure testing is complete and accepted.
- _____ 16. "HAZARDOUS AREA" signs installed where applicable.
- _____ 17. Belt guards installed where applicable.
- _____ 18. Variable frequency drives have been tested by the manufacturer's representative and certified to be in compliance with all of the specified requirements.
- _____ 19. Testing and balancing has been completed, and deficiencies noted have been corrected.
- _____ 20. Special systems have been started and tested, such as: Humidification, laboratory hoods, kitchen hoods, and Owner-furnished items.

TEMPERATURE CONTROLS

- _____ 1. Temperature control panels and devices have been labeled in accordance with the Specifications.
- _____ 2. All control dampers close completely and edge and blade seals form tight seal.
- _____ 3. All control valves have been piped as required by the Drawings.
- _____ 4. Controls systems are completed and all control points are operating and recording properly.

- _____ 5. All temperature control tubing and wiring is installed and secured in accordance with the Specifications and the electrical code.
- _____ 6. Smoke removal fans and/or smoke detectors have been tested for operation and shutdown.
- _____ 7. Freezestats have been tested ensuring fan shutdown and full damper closure.
- _____ 8. Operator training for temperature controls has taken place.
- _____ 9. Refrigerant sensors and equipment room shutdown have been tested.

GENERAL ITEMS

The following specified items have been submitted:

- _____ 1. Record Drawings (to be submitted prior to final payment to the Contractor).
- _____ 2. Operation and maintenance manuals.
- _____ 3. Manufacturer's representative installation check and certification submitted (see list of equipment, Section 23 0500).
- _____ 4. Testing and balancing reports.
- _____ 5. Test kits furnished to Owner.
 - _____ Flow Measuring Devices
 - _____ Flow Balance Valves
 - _____ Flow Control Devices
- _____ 6. Temperature control schematics and sequence of operation.
- _____ 7. Wall-mounted lubrication, valve, and temperature control charts have been installed.

Note to Spec Editor: Coordinate substitution procedures with Architect. If a common substitution request form is utilized, ensure it reflects the Div 23 requirements that are pertinent to mechanical discipline.

DIVISION 23 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS

PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____

Proposed Substitution: _____

Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions? YES ☐ NO ☐
If YES, explain: _____

2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES ☐ NO ☐

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES ☐ NO ☐

5. What affect does substitution have on other trades? _____

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES ☐ NO ☐
If YES, explain: _____

7. Will substitution affect progress schedule? YES ☐ NO ☐
If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES ☐ NO ☐
If YES, explain: _____

9. Does proposed product contain asbestos in any form? YES ☐ NO ☐

SUBMITTED BY: Firm: _____ Date: _____

Address: _____

Signature: _____ Telephone: _____

For Engineer's Use Only

Accepted _____	Not Accepted _____	Received Too Late _____
By: _____	Date: _____	
Remarks: _____		

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL**PROJECT:** _____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for backup and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 23 0501

DEMOLITION

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.

1.2 RELATED SECTIONS

- A. See Section 23 0500, for Common Work Requirements for HVAC.
- B. See Division 1, for Cutting and Patching.

1.3 SCOPE OF WORK

- A. The terms "demolish" and "remove" shall mean disconnect, cart away, and dispose of off site. Components to be demolished or removed include all materials, equipment, building construction, and other components as indicated. Components to be demolished shall become the property of the contractor, and contractor may dispose of them by either landfilling or by selling salvageable parts and recyclable materials to legitimate third parties.
- B. Except as specifically noted, asbestos abatement will be by others, and is not included in this contract. Advise Owner sufficiently in advance of demolition work so that Owner may arrange to have asbestos removed without delaying demolition or construction work.
- C. The Owner retains the first right of refusal on all components to be removed. When requested, remove components carefully and deposit components in locations as directed by the Owner.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 GENERAL

- A. Within four weeks after notice to proceed, and a minimum of two weeks prior to any demolition activities, submit a project schedule indicating all demolition work. Schedule all work to minimize interruptions in utility services to the facility. Interruptions generally will be allowed only outside normal operating hours. Sequence all work in accordance with the drawings and the Project Manual.
- B. Take care not to damage equipment, materials, components, and building construction which is to remain in service. Provide blind flanges, caps, etc, so as to prevent accidental discharge of

water, etc.

- C. Do not interfere with the Owner's access to buildings and equipment. If any activities cause interference which is objectionable to the Owner, contractor shall modify his means and methods, or reschedule those activities outside occupied hours at no additional cost to the Owner.
- D. Where existing systems must remain in service during the construction project, make whatever provisions are necessary to accomplish this. This includes providing blind flanges and caps, temporary insulation, duct caps, etc, to allow for proper system operation.

3.2 EQUIPMENT

- A. General: Disconnect and remove piping, ductwork, controls, power, and equipment supports. Wherever possible, remove equipment as a whole. Do not cut up equipment in place unless approved in advance by the Owner.

3.3 PIPING

- A. Disconnect piping as indicated, and remove all piping not required in the final, upgraded condition of the systems. This includes removal back to the headers and mains which must remain in service. The existing valving may not hold tight. Arrange in advance for shutdowns as required. Provide caps, blind flanges, etc. as indicated on drawings, as required to facilitate construction activities, and as required to facilitate owner's use of the system.
- B. Remove all components in piping system, including valves, fittings, flanges, strainers, anchors, guides, hangers, supports, supplementary steel, attachments to structure, instrumentation, insulation, etc.
- C. Patch all openings in walls, floors, roofs, partitions, gratings, etc, which remain after piping is removed.
- D. Provide vents and drains in the piping which will remain in service, where necessary to facilitate refilling, venting, and future system operation.

3.4 DUCTWORK

- A. Disconnect ductwork as indicated, and remove all ductwork not required in the final, upgraded condition of the systems. This includes removal back to the mains which will remain in service. Arrange in advance for shutdowns as required. Provide caps as indicated on drawings, as required to facilitate construction activities, and as required to facilitate the Owner's temporary and final use of the systems.
- B. Remove all components in ductwork system including fittings, dampers, grilles, registers, diffusers, louvers, hangers, supports, supplementary steel, attachments to structure, instrumentation, insulation, acoustic lining, etc.
- C. Patch all openings in walls, floors, roofs, partitions, gratings, etc, which remain after ductwork

is removed.

3.5 CONTROLS

- A. Remove all controls associated with equipment, piping and ductwork which are to be removed. Controls shall include instrumentation, control panels, wiring, conduits, tubing, supports, and attachments to structure. Where wiring is run in conduit in concealed locations, remove the wiring, cap both ends of conduit, and label conduit as "ABANDONED" at both ends.

3.6 ELECTRIC POWER

- A. Remove all electric power associated with equipment, controls and accessories which are to be removed. Electric power shall include starters, disconnects, wiring and conduit from MCC's and distribution panels to local starters and disconnects, wiring and conduit from local starters and disconnects to equipment, supports, attachments to structure, and concrete housekeeping pads. Label all associated breakers as "SPARE." Where MCC's serve equipment to be removed and no new equipment is to be served from the same starter, leave the starter in place and label it as "Spare Size X Starter."
- B. Where wiring runs in conduit within concealed locations, remove the conductors, cap both ends of conduit, and label conduit as "ABANDONED" at both ends. Where wiring runs below grade, remove conductors, cap conduit at both ends, and abandon in place. Where wiring runs below concrete floor slabs, chip out concrete around conduit, remove conduit to bottom of slab level, and patch floor to match adjacent surfaces.

3.7 EQUIPMENT SUPPORTS

- A. Housekeeping Pads: Remove housekeeping pads for equipment to be removed. Remove all tripping hazards and resurface floor to match surrounding floor.
- B. Equipment Foundations: Remove foundations, remove all tripping hazards, backfill as required, compact to 95% Standard Proctor Density, and pour floor slab to match existing.
- C. Support Steel: Remove all support steel including attachments to building or to grade.

3.8 MEANS OF ACCESS

- A. Remove all service platforms, catwalks, ladders, etc. which are required solely for the equipment, valves, and instrumentation which are being removed as part of this work.

END OF SECTION 23 0501

SECTION 23 0504

PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.
- B. Lead Ban: All systems and system components, pipe, fittings, and fixtures furnished under Division 23 shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.

1.3 SUBMITTAL DATA

- A. Contractor shall furnish complete submittal data for all piping materials, including manufacturer's specifications, certifications, class, type and schedule. Submittal data shall additionally be furnished for pipe hangers and supports, pipe sleeves including sealing and fire safing materials and installation.

PART 2 - PRODUCTS

2.1 PIPE AND PIPE FITTINGS

- A. Piping system materials shall be furnished as specified under the Sections describing the various piping systems. Pipe fittings shall be compatible with the piping systems in which they are installed.
- B. Pipe fittings for steel piping systems shall be weld, screwed or mechanical couplings. Butt weld fittings shall be manufactured by Weld-Bend, Laddish, or equivalent, standard or extra strong as specified in the applicable Sections of this Specification, conforming to ANSI Standard B16.9. All 90° weld elbows shall be long radius unless otherwise specified. Wherever tee connections are required in the piping system, manufacturer's straight or reducing tees shall be utilized. The use of fittings formed from welded pipe or pipe sections will not be permitted. Forged steel "Weld-O-Lets", "Branch-O-Lets", and "Thred-O-Lets", as manufactured by Bonney Forge or equivalent, may be utilized for welded branch and tap

connections up to one-half the size of the main. Forged steel half-couplings conforming to ANSI B16.11 may be used for drain, vent and gauge connections. Flanges shall be forged steel weld neck or slip-on, raised face, Class 150 or 300 as specified in the applicable Sections of this Specification with full face or ring type non-asbestos gasket material suitable for the application.

- C. Socket weld fittings shall be Schedule 40, 2000 pound or Schedule 80, 3000 pound construction, as specified in the applicable Sections of this Specification, conforming to ANSI B16.11, as manufactured by Grinnell or equivalent.
- D. Screwed fittings shall be Class 150 standard or Class 300 extra heavy, black or galvanized, malleable iron or cast iron, as specified in the applicable Sections of this Specification, as manufactured by Grinnell or equivalent. Screwed malleable iron fittings shall conform to ANSI B16.3 and cast iron screwed fittings shall conform to ANSI B16.4. Bushing reduction of a single pipe size or use of close nipples will be permitted.
- E. Pipe fittings for copper piping system shall be wrought copper conforming to ANSI B16.22. Cast brass fittings conforming to ANSI B16.23, may be utilized for sanitary drainage, waste and vent systems, HVAC gravity condensate drainage system, and other non-pressure applications.
- F. Bronze flanges, Class 125 and Class 150, shall conform to ANSI B16.24.
- G. Cast iron fittings for cast iron sanitary soil, waste, and venting piping systems shall be as specified in Division 22.
- H. Ductile iron fittings for ductile iron water service piping systems shall be as specified in Division 22.

2.2 FLOOR, WALL AND CEILING PLATES

- A. Where uncovered, exposed pipes pass through finished floors, finished walls, or finished ceilings, they shall be fitted with chromium plated spun brass escutcheon plates. Plates shall be large enough to completely close the hole around the pipe, and shall be not less than 1-1/2" or more than 2-1/2" larger than the diameter of the pipes. All plates shall be securely held in place.

2.3 UNIONS

- A. Piping 2-1/2" and larger shall be provided with bolted flange union connections. Weld flanges and bolting shall conform to ANSI B16.5. Bronze flanges shall conform to ANSI B16.24. Flange class shall be as specified in the applicable Sections of the Specifications.
- B. Malleable iron grooved joint unions with brass to iron seats, Class 125, 250, or 300, as required by the application and compatibility requirements with the piping system fitting classification, conforming to MSS SP-77 and ANSI B16.39, shall be provided in piping systems 2" and smaller. Copper unions conforming to ANSI B16.22 shall be provided in copper piping systems. Union connections shall be installed at all coils, control valves, equipment

connections, and at other locations shown on the drawings, and required for proper system operation and maintenance.

2.4 DIELECTRIC FITTINGS

- A. Dielectric insulating fittings shall be provided to connect dissimilar metals, such as copper tubing to ferrous metal pipe. Connections 2" and smaller shall be threaded dielectric union conforming to ANSI B16.39. Connections 2-1/2" and larger shall be flange union with dielectric gasket and bolt sleeves, conforming to ANSI B16.42. Insulating fittings will not be required between bronze valves and copper piping, unless otherwise specified.

2.5 PIPE HANGERS AND SUPPORTS

- A. All piping shall be rigidly supported from the building structure by means of hanger assemblies properly selected and sized for the application in accordance with the manufacturer's recommendations and specifications. Pipe hangers shall be Grinnell, B-Line, Erico, or equivalent.
- B. No attempt has been made to show all required piping supports in all locations, either on the drawings or in the details. The absence of pipe supports and details on any drawing shall not relieve the Contractor of the responsibility for furnishing and installing proper hangers and supports throughout.
- C. Piping hangers shall be spaced on the scheduled maximum spacing and shall have hangers not more than one foot from each elbow and other changes in direction or elevation. Provide additional hangers and supports at valves, strainers, in-line pumps adjacent to flexible connections, and other required heavy components. Piping system shall be installed in an approved manner and shall not overload the building structural frame. Contractor shall provide additional hangers and miscellaneous steel supports as may be required to distribute the piping system load over multiple structural members where required or directed. Maximum allowable spacing for steel and copper piping, other than fire protection piping, shall be as scheduled in Table No. 1.

TABLE NO. 1

MAXIMUM SUPPORT SPACING FOR STEEL AND COPPER PIPING SYSTEMS

<u>Steel Piping</u>	<u>- Maximum Spacing</u>
1/2"	- 5'-0"
3/4" and 1"	- 6'-0"
1-1/4" through 2"	- 8'-0"
2-1/2" through 6"	- 10'-0"
8" through 12"	- 12'-0"
<u>Copper Piping</u>	<u>- Maximum Spacing</u>

1/2"	-	5'-0"
3/4" through 2"	-	6'-0"
2-1/2" through 4"	-	8'-0"

- D. Round rods supporting the pipe hangers shall be of the minimum dimensions as scheduled in Table No. 2. Hanger rods shall be hot-rolled steel, ASTM A-36 or A575, galvanized, all-thread. Provide for controlling level and slope by turnbuckles or other approved means of adjustment and incorporate locknuts.

TABLE NO. 2

HANGER ROD SIZE FOR PIPE HANGER SUPPORTS

1/2" to 2" pipe	-	3/8" rod
2-1/2" to 3" pipe	-	1/2" rod
4" to 5" pipe	-	5/8" rod
6" pipe	-	3/4" rod

- E. Cast iron soil, waste and vent piping shall be provided with steel clevis type hangers. Grinnell Fig. 590 at each pipe joint and at each fitting.
- F. Hangers, clamps and other support materials in contact with copper piping shall be copper or copper plated to prevent electrolysis. Hangers for copper piping shall be copper plated adjustable ring type Grinnell Fig. CT-269, adjustable swivel ring, Grinnell Fig. CT69, Fig. CT-65 or adjustable clevis type or equivalent. Provide minimum 10 mil plastic wrap around copper pipe at any ferrous point of attachment including trapeze hangers, clamps, and other supports.
- G. Hangers for steel shall be steel clevis type hangers, Grinnell Fig. 260 or equivalent.
- H. Where piping is installed side by side, the Contractor may support the piping utilizing trapeze type hanger assemblies. Horizontal trapeze member shall be galvanized steel channel, not less than 1-1/2" x 1-1/2" x 12" gauge, or Unistrut. Contractor shall provide heavier steel members as required for the load to be supported and the distance span. Trapeze hangers shall not be utilized for plumbing drain waste and vent piping. Hanger rods shall be as specified above, properly sized for the load supported but not less than 5/8" diameter. Un-insulated copper piping shall be isolated from the steel trapeze. Individual pipe shall be guided on the horizontal member at every other hanger point with 1/4" U-bolt fabricated from steel rod. Provide full circle galvanized sheetmetal insulation shield for insulated piping at trapeze hangers with U-bolt guide and galvanized sheetmetal insulation half-shield at other trapeze hangers. Insulation shield shall be 18 gauge minimum, Grinnell Fig. 167 or equivalent.
- I. Where shown on the drawings and as required for the proper control of the system expansion and contraction, and for heating hot water provide rolled type supports. Roller hangers shall be Grinnell Fig. 181 or equivalent and roll support for trapeze hangers and pipe racks shall be Grinnell Fig. 271, Erico, or equivalent complete with base plate.
- J. Special piping supports including tunnel support racks, wall support racks, floor mounting

pedestal type supports shall be provided as indicated on the drawings, and as required for the proper support for the piping systems.

- K. Vertical piping shall be supported at each floor level by means of riser clamps, Grinnell Fig. 261 and Fig. G-121, Erico, copper clad for copper piping systems, or equivalent. Proper allowance for the expansion and contraction of the vertical risers shall be provided. Contractor shall submit shop drawings indicating proposed method for support and control of expansion and contraction of vertical piping. See Section 23 0505 for expansion joints, expansion compensators, pipe guide and pipe anchors.
- L. The use of pipe hooks, chains, or perforated iron for pipe hanger supports will not be permitted.
- M. All insulated piping systems specified in Section 22 0700, Plumbing Insulation and Section 23 0700, HVAC Insulation, shall be provided with individual hangers sized to encircle the insulation. See applicable sections for insulation thickness requirements. The specified piping systems where supported by means of trapeze hangers shall not rest directly on the trapeze horizontal members. The insulation at hangers and trapeze hangers shall be protected by means of insulation shield, Grinnell Fig. 167, Erico, or equivalent. Grinnell Fig. 160, Erico, or equivalent, curved steel pipe saddle, shall be provided at roll hangers. Contractor shall provide section of high density calcium silicate insulation or thermal hanger shields as manufactured by Pipe Shields, Inc., or equivalent, at all insulation piping system hanger and support points for piping 1-1/2" or larger.
- N. Attachment of piping hangers to the building structure shall be provided in a manner approved by the Engineer. The Contractor shall provide concrete inserts in the building construction at the time the concrete is poured and hangers shall be attached to these inserts. Self-drilling expansion anchors, Federal Specification FF-S-325, may be used in concrete construction not less than 4" thick. Applied load shall not exceed manufacturer's approved ratings. Power driven fasteners may be used in existing concrete or masonry not less than 4" thick where approved by the Architect. Attachment to steel construction shall be by means of beam clamps Grinnell Fig. 131, Erico, C-clamps Grinnell Fig. 86, Erico, or equivalent may be utilized for attachment of light loads as approved by the Structural Engineer. Attachment to wood construction shall be by means of wood screws or lag bolts.

2.6 PIPE SLEEVES

- A. Pipe sleeves shall be furnished and set by the Contractor and he shall be responsible for their proper and permanent location. Piping will not be permitted to pass through footings, beams or ribs except with written consent of the Architect. Pipe sleeves shall be installed and properly secured in place at all points where pipes pass through gypboard stud walls and concrete, and masonry construction and at all fire and smoke rated walls and partitions. Pipe sleeves, except sleeves in footings and beams shall be equal to Pipe Shields Incorporated Model WFB for walls, DFB for decks, or QDFB for corrugated decks, or equivalent. Each sleeve shall be adjustable, with annular spacing packed with UL approved mineral fiber fire safing material. Where insulated piping is installed, calcium silicate inserts to match the insulation thickness and extending 1" past the sleeve on both ends, shall be provided. Pipe sleeves in concrete and masonry construction, footings and beams shall be Schedule 40 black steel pipe. Pipe sleeves in gypboard construction shall be galvanized steel metal. Sleeves shall be not less than 1" or

more than 2" larger in diameter than the pipe to be installed. Pipe sleeves in floors shall extend 2" above finished floor in chases and equipment room areas unless otherwise approved by the Architect. Openings between piping and sleeves shall be made watertight with plastic cement installed to a minimum depth of 2". Where pipes pass through exterior walls, the annular space between the wall and the pipe shall be sealed by sealing elements made of synthetic rubber, pressure plates, and cadmium plated bolts as manufactured by Link-Seal, or equivalent.

- B. Un-insulated piping passing through fire walls, smoke wall, sound control walls and air plenum separations shall be sealed airtight to the adjacent construction by means of UL approved fireproof caulking materials.
- C. Insulated piping passing through fire walls and smoke walls shall be provided with a section of UL approved fire safing insulation to match the required insulation thickness or Pipe Shields, Inc. pipe shield sleeves as specified above at the required wall penetrations. The space between the piping sleeve penetration and the adjacent wall Construction shall be sealed airtight with UL approved fireproof caulking material. Penetrations of gypboard sound walls and air plenum separators shall be caulked airtight with an approved caulking compound.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Provide and erect, according to the best practices of the trade, all piping shown on drawings and required for the complete installation of these systems. The piping shown on the drawings shall be considered as diagrammatic for clearness in indicating the general run and connections, and may or may not in all parts be shown in its true position. The piping may have to be offset, lowered or raised as required or as directed at the site. This does not relieve the Contractor from responsibility for the proper erection of systems or piping in every respect suitable for the work intended as described in the specifications. In the erection of all piping, it shall be properly supported and proper provisions shall be made for expansion, contraction and anchoring of piping. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing all windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate installation will not be permitted. All pipes shall have burrs and/or cutting slag removed by reaming or other cleaning methods. All changes in direction shall be made with fittings. All open ends of pipes and equipment shall be properly capped or plugged to keep dirt and other foreign materials out of the system. Plugs of rags, wool, cotton waste or similar materials may not be used in plugging. All piping shall be arranged so as not to interfere with removal and maintenance of equipment or filters or devices; and so as not to block access to manholes, access openings, etc. Flanges or unions as applicable for the type of piping specified shall be provided in the piping at connections to all items of equipment including refrigeration machines. All piping shall be so installed to ensure noiseless circulation. All valves and specialties shall be so placed to permit easy operation and access, and all valves shall be regulated, packed and adjusted at the completion of the work before final acceptance. All piping shall be erected to ensure proper draining.

3.2 JOINTS

- A. Caulked Joints: Caulked joints in hub-and-spigot piping and vent piping shall be packed firmly with white oakum, "Sealite No. 110," or hemp and caulked with pure molten lead not less than 1" deep. Resilient molded gasket joints or "Ty-Seal" may be used in lieu of lead and oakum for sanitary soil, waste and vent piping. No-hub pipe and fittings will be accepted with the exception that no-hub pipe and fittings shall not be allowed for buried installation.
- B. Screwed Joints: Shall have American Taper pipe threads. Ream pipe ends and remove burrs after threading. Make up joints using Teflon tape or other approved compound applied to the male threads only.
- C. Solder Joints: Copper tubing shall be cut square and burrs removed. Both inside of fittings and outside of tubing shall be well cleaned before sweating. Care shall be taken to prevent annealing of fittings and hard drawn tubing when making connections. Joints for sweated fittings shall be made with a non-corrosive paste flux and solid 95-5 tin-antimony wire solder, unless otherwise specified. Cored solder will not be permitted. 50/50 lead solder shall not be

permitted for any applications.

- D. Welded Joints: On black steel piping 2-1/2" and above in size, the joints may be welded. Welding shall be done using either gas or electric welding equipment. Certified welders shall be used. Welders shall be certified in accordance with Section IX of ASME Boiler and Pressure Vessel Code, latest edition. All pipe surfaces shall be thoroughly cleaned before welding. Each joint shall be beveled before being welded. Piping shall be securely aligned and spaced, and the width of circumferential welds shall form a gradual increase in thickness from the outside surface to the center of the weld. All fittings used in the welded piping systems shall be standard ASA fittings, and shall be of standard pipe thickness. The Contractor shall provide a fireproof mat or blanket to protect the structure and adequate fire protection at all locations where welding is done. The use of fittings formed from welded pipe sections will not be permitted.
- E. Flanged Joints: Flanged joints shall conform to the American Standard for cast iron flanged pipe fittings, Class 125, 150 or 300 as specified in the applicable Sections of these specifications. Gaskets shall be full face or ring type, non-asbestos, suitable for the service on which used.

3.3 PUMP AND EQUIPMENT CONNECTIONS

- A. All piping connecting to pumps and other equipment whether connected utilizing flexible connectors or with solid pipe connectors, shall be installed without strain at the pipe connection of the equipment. The Contractor shall be required, if so directed, to disconnect piping to demonstrate that piping has been so connected.

3.4 EXPANSION AND CONTRACTION

- A. The Contractor shall make all necessary provisions for expansion and contraction of piping with offsets or loops and anchors as required to prevent undue strain. Contractor shall provide shop drawings for proposed method and arrangement for control of expansion and contraction of piping. See Section 23 0505 for expansion joints, expansion compensators, pipe guides and pipe anchors.

3.5 PROTECTIVE COATINGS

- A. All underground steel pipe shall be wrapped with "Scotchwrap" No. 50 tape or equivalent, to give not less than two complete layers on the entire underground piping system, or piping shall have X-Tru-Coat factory applied plastic protective covering.

3.6 FLUSHING, DRAINING AND CLEANING PIPE SYSTEMS

- A. The Contractor shall flush out all water systems with water before placing them in operation. Other systems shall be cleaned by blowing them out with compressed air or nitrogen. After systems are in operation and during the test period, all strainer screens shall be removed and thoroughly cleaned.
- B. See applicable HVAC piping system specification sections for chemical cleaning of piping

systems.

3.7 TESTING

- A. Before any insulation is installed or before piping is covered or enclosed, all piping systems shall be tested and proven tight at not less than 150% of the maximum service pressure which the piping systems will be required to handle. Piping system tests shall be as specified in the applicable sections of this Specification. All tests shall be witnessed and approved by the Architect.
- B. All labor, material, and equipment required for testing shall be furnished by the Contractor. The Contractor shall be responsible for all repairs and retesting as required. All instruments and other equipment whose safe pressure range is below that of the test pressure shall be removed from the line or blanked off before applying the tests. To perform tests, all lines shall be flushed and cleaned.
- C. All safety measures required by codes or ordinances or reasonably applicable to the situation shall be provided by the Contractor in conjunction with the testing of the piping systems.
- D. Equipment or piping to be pressure tested shall not be insulated, covered, or concealed prior to that test. Underground piping may be partially backfilled prior to pressure test when required for application of the test except that joints shall remain exposed until after the test. Tie rods, clamps etc., shall be in place and fastened.
- E. Tests shall not be used to establish pressure ratings.
- F. Protect all piping and equipment against over pressure, collapse from vacuum, and hydraulic shock during the filling, testing and draining procedures. Seats of iron valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Pressure tests against other closed valves shall not exceed twice the normal rating.
- G. Apply test pressure only after the system and test medium are at approximately the same temperature, preferably not less than 60°F. Note that some applicable codes may require testing above a specified minimum temperature.
- H. Remove from the system all pumps, turbines, traps, expansion joints, instruments, control valves, safety valves, rupture discs, orifice plates, etc., which might be damaged by the test. Also remove all items such as orifice plates which might trap air in a system to be hydrostatically tested. Disconnect all instruments and air lines where copper tubing starts.
- I. Systems may be separated into sub-systems for testing if such action will expedite or simplify the testing.
- J. During hydrostatic testing of lines, provide temporary supports to prevent overstressing supports or hangers. When tests are completed, remove all temporary supports, locks, stops, etc., and adjust supports for their cold load and alignment.

END OF SECTION 23 0504

SECTION 23 0505

PIPING SPECIALTIES

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform to applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.
- B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements.
- B. Section 23 0504, Pipe and Pipe Fittings.
- C. Section 23 0523, Valves.

1.3 SUBMITTAL DATA

- A. Furnish complete submittal data for all piping specialties including manufacturer's specifications, performance characteristics, ratings, installation instructions, certifications and approval of listing agencies, wiring diagrams, and selection analysis.

PART 2 - PRODUCTS

2.1 STRAINERS

- A. Strainers suitable for the application shall be furnished and installed on the high pressure side of pressure reducing valves, pressure regulating valves, suction side of pumps, inlet of indicating and control instruments and equipment subject to sediment damage, and as shown on the drawings. Strainers shall be "Y"-type unless basket strainers are indicated. Tee-type strainers will not be accepted. Strainer element shall be removable without disconnecting piping. Screens shall be Type 304 stainless steel with 1/8 inch perforations for water service. Every strainer shall be provided with a blow-off connection not less than 1/2" NPT and provided with a ball valve the full size of the strainer outlet tapping. Strainers located outside

of mechanical equipment rooms and above ceilings shall be provided with hose connection and cap on the outlet of the blowoff valve. Strainers shall be Spirax Sarco, Armstrong, Febco, Grinnell, Hoffman, Keckley, Metraflex, Mueller, Yarway, or equivalent.

- B. Strainers 2" and under for copper piping systems shall be threaded connection, bronze body, 250 PSIG maximum working pressure, suitable for steam, oil, gas and liquid service, Sarco BT or equivalent.
- C. Strainers 2" and under for steel piping systems shall be threaded connection, bronze body, as specified above or cast iron body as specified herein, except all strainers in galvanized steel domestic water systems shall be bronze body. Cast iron strainers shall be threaded connection, 250 PSIG maximum working pressure, suitable for steam, oil, gas and liquid service, Sarco IT or equivalent.
- D. Strainers 2-1/2 inches or larger shall be standard flanged connection ANSI-125, cast iron body, suitable for steam, oil, gas, and liquid service, 125 maximum working pressure at 353° F maximum temperature, Sarco CI-125
- E. Basket strainers 2" and larger shall be standard flanged ANSI-125, cast iron body bolted cover, Type 304 stainless steel screen, suitable for steam or liquid service, 125 maximum working pressure at 353°F maximum temperature, Sarco 528-B-125, or equivalent.]

2.2 PRESSURE GAUGES

- A. 2.5-inch glycerin filled, SS case, 1.5% accuracy, dual scale (PSI & KPA), bronze bourdon tube and 0.25-inch NPT connection, brass snubber with properly selected filter disc for the application, and needle valve with knurled brass or ABS plastic handle. Provide multiple needle valves where a single pressure gauge is used to measure pressure at multiple points. Provide siphon for steam gauges. Winters, Weiss, Marshalltown, Ashcroft, Trerice, Weksler, or equivalent.
- B. Select pressure range as indicated on the drawings, or if not indicated select so that the normal operating pressure is approximately 50% of the scale range. Provide compound and vacuum gauges where required by the application.
- C. Install gauges so they are easily readable from normal operator level. Where the sensing location is not convenient to the operator, install the gauge and needle valves at a location easily read from normal operator level, extend piping from there to the sensing point on the main pipe, and provide a ball valve for isolation at the main. In addition, provide drain and vent valves to facilitate removing air and water from the sensing line.

2.3 THERMOMETER AND THERMOMETER WELLS

- A. Either liquid filled or digital type, vari-angle, 3-1/2" stem for pipe sizes through 6" and 6" stem for pipe sizes 8" and larger, dual scale (degrees F & C), separable brass socket, extension neck where installed in insulated piping, and accuracy 1% of range. Winters, Weiss, Moeller, Trerice, Weksler, Duro, or equivalent.

1. Liquid Filled Type: 9" case, straight form, V-shaped, high pressure die cast aluminum, baked enamel finish, with heavy glass-protected front firmly secured with spring action, and organic liquid filled magnifying lens. Winters 9IT or approved equal.
2. Digital Type: May be used both indoors or in outdoor locations not exposed to sunlight, high impact ABS plastic housing, suitable for operation at 16 Lux. Winters 9IT or approved equal.

B. Ranges: Provide the following ranges except where otherwise indicated:

Heating Water 30-240 degrees F

2.4 MANUAL AIR VENTS

- A. Provide manual air vents at locations indicated on the drawings, at the high point of all liquid piping system and as otherwise required for proper air elimination and liquid circulation.
- B. Manual air vents shall be 1/2" brass ball valves as specified in Section 23 0523. Provide brass hose connection and plug on valve outlet.

2.5 AUTOMATIC AIR VENT

- A. Provide automatic air vents for all separators, at the high point of all hydronic systems and at locations indicated on the drawings. Automatic air vents shall be 3/4" size, minimum. Provide manual shut-off ball valve between automatic air vent and piping system. Automatic air vents shall be float type, 150 PSIG maximum working pressure, 3/4" NPT system connection, Amtrol Model No. 720, Taco, Armstrong, Watson-McDaniel, Hofmann, or equivalent.

2.6 MANUAL DRAIN VALVES

- A. Provide manual drain valves at locations indicated on the drawings, at the low points of all liquid piping systems, and as otherwise required for proper draining of systems. Manual drain valves shall be sized as shown on the drawings but not less than 3/4" size, brass ball valve, as specified in Section 23 0523. Pipe discharge from drain valves to floor drain, floor sink, or as otherwise directed for indirect discharge into sanitary sewer system. For drain valves located above ceiling or in location outside mechanical equipment areas provide brass hose connection and cap for valve discharge.

2.7 TEMPERATURE AND PRESSURE TEST PLUGS

- A. 0.25 or 0.5-inch NPT with brass body, EPDM core, and brass gasketed cap. Winters, Peterson, or approved equal. Supply one pressure/temperature test kit with two 4" Duro #105 pressure gauges of 1% accuracy and ranges as required by application; and two 2" Tel-Tru #39R Bi-metal thermometers with 8" stem, 1% accuracy, and ranges as required by the applications; and a protective carrying case.

2.8 FLOW BALANCE VALVE

- A. Furnish and install calibrated balance valve equivalent to Bell and Gossett "circuit-setter," Griswold, Taco, Armstrong, or equivalent at locations indicated on the drawings. Balance valves shall be brass or cast iron body, NPT or sweat connections through 3" size and flanged connections above 4" size, 125 PSIG working pressure minimum. Balance valve shall be equipped with two brass readout valves with integral EPT insert and check valve designed to minimize system fluid loss during balancing and monitoring process. Each valve shall be provided with a calibrated nameplate permitting accurate system balance. Flow balance valves shall be not less than full line size with maximum pressure drop of 10 feet. Provide one readout kit including flow meter, readout probes, hoses, flow charts and calculators, all contained in carrying case.

2.9 AUTOMATIC FLOW LIMITING VALVES

- A. To maintain constant flow within 5 percent over a range of 2-32 psid. Bronze or cast iron body, stainless steel cartridges, two pressure readout ports with quick disconnect valves and caps, SS identification tag marked with rated flow. Valves through 2 inch size shall be threaded connection, valves over 2 inches shall be wafer type; 150 psig rated. Supply one readout kit including flow meter, hoses and flow charts all contained in carrying case. Size valves for required flows. Griswold, FDI, or approved equal.

2.10 FLEXIBLE CONNECTORS

- A. Furnish and install flexible connectors at locations indicated on the drawings and at all piping connections associated with equipment mounted on or hung from vibration isolators. Flexible connectors shall be constructed of multiple ply nylon cord fabric and neoprene, operating pressure 150 PSIG at 220°F through 12" size and operating pressure of 125 PSIG at 220°F for sizes 14" through 24". Provide butyl or Hypolon liner and applications with fluid temperatures in excess of 225°F.
- B. Flexible connectors shall be single or twin sphere with Class **[150] [300]** flange connections for sizes 2-1/2" and larger and threaded connections with galvanized female unions for sizes 3/4" through 2". Mason Industries MFTCR, Hyspan, Metra-Flex, Keflex, Proco, or equivalent. Flexible connectors required for outdoor installation shall be braided **[brass] [stainless steel]** type.
- C. Installation of flexible connectors shall be in strict accordance with manufacturer's recommendations. Spacing between piping system flanges shall be based on the flexible connector's expanded length corresponding to the system's operating pressure. Control rods or cables shall be provided for units installed in unanchored applications where system operating pressure and dynamic forces exceeds manufacturer's recommendations for unrestrained installations.

2.11 CHEMICAL WATER TREATMENT

- A. Chemical water treatment for hydronic systems exist in Boiler Room.

2.12 SOLENOID VALVES

- A. See Section 23 0500, Common Work Requirements, and Section 23 0549, HVAC and Electrical Installation Coordination, for requirements associated with electrical control and power wiring for solenoid valves. Furnish hazardous duty enclosure where required by the application.

2.13 FLOW SWITCHES

- A. Furnish and install flow switches where required for protection and/or monitoring of mechanical equipment including water chillers, boilers, pumps, etc. and as otherwise shown on the equipment schedule, and the drawings.
- B. Flow switches shall be either paddle type or differential pressure type as required by the application and as shown on the drawings, except differential pressure type flow switches shall be utilized for water chillers and other applications where minor pressure fluctuation could cause nuisance tripping of equipment operation.
 - 1. Paddle type flow switch shall be McDonnell and Miller Model FS7-4 Series, or equivalent designed for industrial duty, brass body and trim, 300 PSIG maximum working pressure, paddle size as required for application, single pole double throw switches, with electrical rating of 7.4 full load amps at 115 VAC. Provide hazardous duty enclosure where required by the application. Flow switches shall be installed in a horizontal pipe with inlet and outlet conditions necessary to provide trouble-free operation.
 - 2. Differential pressure flow switch shall be Honeywell Model 406 Series or equivalent, adjustable pressure differential setting, dustproof mercury switch enclosure, 1/4" NPT bellows connections, single pole, single throw switch, with electrical rating of 7.2 full load amps at 115 vac. Differential pressure switches shall be properly supported on the equipment controlled or wall mounted adjacent to the equipment or piping system.

2.14 EXPANSION JOINTS

- A. Furnish and install corrugated bellows expansion joint, Hyspan Series 1500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, self-equalizing, **150 PSIG working pressure** at 850°F, **Class 150** ASA flange connections 1-1/2" size and above, single or dual center base configuration as shown on the drawings, constructed of corrugated Type 304 or 321 stainless steel, ring controlled, with integral stainless steel or Monel sleeve, and removable carbon steel external housing to protect bellows and support insulation. Furnish limit rods to prevent expansion joint from exceeding rated travel. Joint design shall be for maximum flexibility over 10,000 cycles minimum.
- B. Expansion joint sizing and installation shall be as shown on the drawing and as recommended by the manufacturer.
- C. Expansion joints shall be insulated with flexible 2" minimum thickness of high temperature fiberglass blanket insulation furnished with joint and installed under the external protective housing.
- D. Contractor shall carefully check expansion joint limit rods and make adjustments as required to

ensure proper joint movement and operation.

2.15 EXPANSION COMPENSATORS

- A. Furnish and install expansion compensators, Hyspan series 8500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, stainless steel laminated bellows with stainless steel or carbon steel shroud, 175 PSIG pressure rating at 250°F, 2 inch straight line expansion and 1/2 inch contraction. Furnish copper tube with sweat ends for compensators installed in copper piping systems. Furnish standard wall carbon steel pipe tube for compensators installed in steel piping systems, threaded connectors for sizes 2" and smaller and Class 150 ASA flange connection for sizes 2-1/2" or larger.
- B. Expansion compensators sizing and installation shall be as shown on the drawings and as recommended by the manufacturer.

2.16 PIPE ALIGNMENT GUIDES

- A. Furnish and install factory fabricated steel pipe alignment guides, Hyspan Series 9500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, to maintain the longitudinal position of pipe centerline between expansion joints and compensators with axial restraint. Alignment guides shall consist of a bolted two-section outer cylinder and base with two-section guiding spider bolted tight to the pipe guide. Guide and spider shall be sized to clear pipe and pipe insulation and long enough to prevent over travel of spider and cylinder. Guides shall not be used for pipe support.
- B. Alignment guides shall be arranged and installed as shown on the drawings and as recommended by the manufacturer.

2.17 PIPE ANCHORS

- A. Pipe anchors shall be constructed of welded steel as detailed on the drawings.
- B. Pipe anchors shall be arranged as shown on the drawings and as required to properly control/piping system expansion and contraction in conjunction with system flexibility due to off-sets, bends, and loops and expansion joints and compensators.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All specialties shall be installed in accordance with the best standard practices and as recommended by the manufacturer.
- B. Install thermometers so they are easily readable from operator level.
- C. Where thermometers, gauges, vents and test fittings occur in insulated piping systems or on insulated equipment, extension necks shall be provided to extend beyond the insulation.

3.2 AIR VENTS

- A. Manual air vents shall be installed as specified herein and at the high points in all piping systems.
- B. Automatic air vents shall be installed as specified herein and at locations indicated on the drawings. Automatic air vents shall be installed level and in accordance with manufacturer's directions to properly vent system, complete with individual isolation valves.

3.3 STRAINERS

- A. All strainer screens, including basket strainers and suction diffusers, shall be removed and cleaned prior to commencing testing and balancing work and shall be maintained clean through project final acceptance by the Owner. Suction diffuser start-up strainers shall be removed prior to final system testing and balancing work.

3.4 TEST AND ADJUSTMENT

- A. Field adjust all water pressure regulating valves, flow switches, water level controls, and specialties to provide required system operation.
- B. Field test and verify the operation of all safety devices including water and steam relief valves and temperature and pressure relief valves.

END OF SECTION 23 0505

SECTION 23 0523

VALVES

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.
- B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.
- C. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 23 0500 for Common Work Requirements for HVAC.
- B. Section 23 0504 for Pipe and Pipe Fittings.
- C. Section 23 2313 for Refrigerant Piping System.
- D. Section 23 0900 for Automatic Temperature Control Valves.

1.3 SCOPE

- A. Contractor shall furnish and install all valves and accessories necessary for satisfactory operation of the systems.

1.4 VALVE REQUIREMENTS

- A. All Gate, Globe, Check, Ball valves shall be manufactured by Milwaukee, Nibco, Apollo, Stockham, Powell, Crane, Tyco-Grinnell, or equivalent.
- B. All lubricated plug valves shall be as manufactured by Rockwell, Walworth, Homestead, or equivalent.
- C. Butterfly valves shall be as manufactured by Milwaukee, W. C. Norris, Centerline, Crane, Demco, Keystone, Tyco-Grinnell, Victaulic, Nibco, or Dezurik, [**Kitz**], or equivalent. Butterfly valves may be used for closed circuit chilled water, heating hot water (200°F maximum) run-around coil and heat pump circulating water systems and for condensing water systems.

Butterfly valves shall not be used for domestic water or other non-specified service.

- D. Ball valves shall be utilized in lieu of gate valves and globe valves for all HVAC and plumbing systems for sizes 2" and smaller.
- E. Butterfly valves may be substituted for gate, globe and ball valves for specified services, and for other services as may be approved by the Engineer.
- F. All valves of the same type, shall be products of a single manufacturer unless otherwise approved by Owner's Representative.
- G. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

PART 2 - PRODUCTS

2.1 GENERAL SERVICE VALVES, HVAC AND PLUMBING SYSTEMS

- A. Gate Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, solid disc, rising stem, gland packed, non-asbestos packing. Milwaukee 148 (Threaded) or equivalent; Milwaukee 149 (Solder), or equivalent.
- B. Gate Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, solid wedge disc, rising stem, union bonnet, gland packed, non-asbestos packing. Milwaukee 1151 (Threaded) or equivalent; Milwaukee 1169 (Solder), or equivalent
- C. Gate Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, solid wedge disc, rising stem, union bonnet, gland packed, non-asbestos packing. Milwaukee 1184 (Threaded) or equivalent.
- D. Gate Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B cast iron, flanged ends, Class 125 construction, OS & Y Type, rising stem, bronze trim, non-asbestos packing. Milwaukee F2885 or equivalent.
- E. Gate Valves - 2-1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be of ASTM A-126 Class B cast iron, flanged ends, Class 250 construction, OS & Y Type, rising stem, bronze trim, non-asbestos packing. Milwaukee F2894 or equivalent.
- F. Globe Valves - 2" and Smaller, Class 125: Valves 2-1/2" and smaller shall be of ASTM B-62, Class 125 construction, bronze trim, gland packed, non-asbestos packing. Milwaukee 502 (Threaded), or equivalent; Milwaukee 1502 (Solder) or equivalent.
- G. Globe Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be of ASTM B-62, bronze, Class 150 construction, bronze trim, composition disc, union bonnet, gland packed, non-asbestos packing. Milwaukee 590 (Threaded) or equivalent; Milwaukee 1590 (Solder), or equivalent.
- H. Globe Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be of ASTM B-62, bronze, Class 300 construction, bronze trim, union bonnet, gland packed, non-asbestos

packing. Milwaukee 572 (Threaded) or equivalent

- I. Globe Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and Larger shall be of ASTM A-126, Class B cast iron, flanged ends, Class 125 construction, bolted bonnet, gland packed, non-asbestos packing. Milwaukee F2981M or equivalent.
- J. Globe Valves - 2-1/2" and Larger, Class 300: Valves 2-1/2" and larger shall be of ASTM A-126, Class B cast iron, flanged ends, Class 300 construction, bolted bonnet, gland packed, non-asbestos packing. Milwaukee F2983 or equivalent.
- K. Check Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, Y-pattern, swing type design, teflon seat, disc for steam service, Buna-N for water service. Milwaukee 509 (Threaded) or equivalent; Milwaukee 1509 (Solder) or equivalent.
- L. Check Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, Y-pattern, swing type design, bronze seat, composition disc, teflon seat disc for steam service, Buna-N for water service. Milwaukee 510 (Threaded) or equivalent; Milwaukee 1510 (Solder) or equivalent.
- M. Check Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, Y-pattern, swing type design, bronze regrinding disc. Milwaukee 507 (Threaded) or equivalent.
- N. Check Valves - 2 1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B, cast iron, flanged ends, Class 125 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2974M or equivalent.
- O. Check Valves - 2 1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be of ASTM A-126 Class B, cast iron, flanged ends, Class 250 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2970 or equivalent.

2.2 BUTTERFLY VALVES

- A. Valves 2-1/2" and larger shall be full lug pattern, ASTM A-216, Class B cast iron body, 416-SS stems, aluminum/bronze disc, EPDM liner and seats (-30°F to 275°F) w/rigid phenolic cartridge, 200 PSIG working pressure with Bubble tight shut-off. Valves shall be for mounting between flanges with lugs drilled and tapped so that pipe may be disconnected on either side of valve with opposite end remaining under pressure. Milwaukee ML-123-E or equivalent.
- B. Valves 4" and smaller shall be provided with level handler operator with spring loaded lock stops. Valves 5" and larger shall be furnished with manual gear operator with hand wheel.
- C. Valves installed for insulated services shall be provided with extensions, as required, such that operator does not interfere with insulation or insulation jacketing.
- D. Butterfly valves furnished for use in grooved piping system shall meet the material specification requirements as specified herein.

2.3 BALL VALVES

- A. Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, 600 PSI W.O.G. Two-piece body, chrome plated ball, blowout proof stem, reinforced TFE seats, non-asbestos packing. Milwaukee BA-100 (threaded) or equivalent. Milwaukee BA-150 (solder) or equivalent.
- B. Valves installed on insulated services shall be provided with extensions, as required, such that operator does not interfere with insulation or insulation jacketing. Cutting or notching of the insulation or bending of handles shall not be permitted.

2.4 BALANCE VALVES

- A. Valves 2" and smaller: Ball valve, bronze, Class 150 construction, 600 PSI W.O.G., Two piece body, Milwaukee BA-100 (threaded). Milwaukee BA-150 (soldered), as specified herein or equivalent.
- B. Valves 2-1/2" and larger: Lubricated plug valve, cast iron construction, 175 PSI W.O.G., Class 125 flange connections, level handle for valves 4" and smaller, manual gear operator with handle wheel for valve 5" and larger. Walworth No. 1797F or equivalent.
- C. Valves 2-1/2" and larger:
 - 1. Butterfly valve, full lug pattern, as specified herein.
 - 2. Furnish level handle with infinite throttling positions and locking device for securing handle in any position for valves 4" and smaller and manual gear operator with hand wheel for valves 5" and larger.

2.5 MANUAL AIR VENTS AND DRAIN VALVES

- A. For manual air vents and drain valves, see Specification Section 23 0505, Piping Specialties.

2.6 NON-SLAM SILENT CHECK VALVE

- A. Check valves for pump discharge and other required non-slam silent operation, shall be center guided, suitable for vertical or horizontal installation position, cast iron in semi-steel body, bronze disc and trim, stainless steel spring, Buna-N seats, Class 125 or 250 construction, as required by the application, wafer or globe flanged pattern for valves 2" through 10" size and flanged pattern for valves 12" and larger. Milwaukee 1400 Series (wafer) or equivalent. Milwaukee 1800 Series (globe) or equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All valves shall be installed in locations which will allow easy operation and facilitate maintenance.
- B. Gate and Globe valves shall be installed with stems horizontal.

END OF SECTION 23 0523

SECTION 23 0549

HVAC AND ELECTRICAL INSTALLATION COORDINATION

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED DIVISIONS AND SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 0900, Facility Management System.
- C. Division 26 for Electrical.
- D. Division 28 for Electronic Safety and Security.

1.3 SCOPE

- A. It is the intention of this section to summarize the coordination of effort defined in the related sections and divisions of this specification.
- B. If there is a conflict between this Section and other Sections and Divisions of this specification, this Section shall be the governing and decisive Section.
- C. Make all connections to motors and controls for equipment supplied and/or installed under Division 23 according to Table 1 on the following page.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. No work shall be performed until the reviewed and marked submittal data have been reissued to the Contractor, unless written permission is obtained from the **[Architect]**.

TABLE 1

Item or System	Note	Supplied By (3)	Installed By (3)	Powered By	Control Field Wiring By
Equipment Motors		Div. 23	Div. 23	Div. 26	N/A
Motor Control Center Including Starters, Pilot Lights, Heater, Switches, Auxiliary Contacts, and Internal Control Wiring		Div. 26	Div. 26	Div. 26	Div. 23
Stand Alone Motor Starters (outside motor control centers)	(1)	Div. 26	Div. 26	Div. 26	Div. 23
Variable Frequency Drives (VFD's)		Div. 23	Div. 23	Div. 26	Div. 23
Fused and Non-Fused Disconnects	(1)	Div. 26	Div. 26	Div. 26	N/A
Control Relays & Control Transformers	(1)	Div. 23	Div. 23	Div. 26	Div. 23
Water Chillers		Div. 23	Div. 23	Div. 26	N/A
Min. Outside Air Units Including Mixing Dampers		Div. 23	Div. 23	Div. 26	Div. 23
[Rooftop] A/C Units Including Mixing Dampers		Div. 23	Div. 23	Div. 26	Div. 23
HVAC Unit Smoke Detectors		Div. 28	Div. 23	Div. 28	Div. 28
Fire/Smoke Control Dampers & Smoke Dampers		Div. 23	Div. 23	Div. 26	Div. 28
Supply, Return & Exhaust Fan with unit mounted 115 VAC 2-position damper actuators interlock with fan motor/starter		Div. 23	Div. 23	Div. 26	N/A
Non-FMS Control Devices Including Wall Switches, Timers, Thermostats		Div. 23	Div. 23	Div. 26	Div. 26
Facility Management System (FMS)	(2)	Div. 23	Div. 23	Div. 23	Div. 23
Fire Alarm System & Interface w/HVAC System		Div. 28	Div. 28	Div. 28	N/A

TABLE NOTES:

1. Unless specified to be supplied with the equipment
2. Division 26 shall provide 120 VAC power to each mechanical space and the central plant as indicated on the drawings. Any additional power, transformers, and distribution shall be provided by the Section or Division indicated.
3. Division 23 indicates the HVAC contractor or their designated representative including equipment suppliers, sub-contractors, etc.

END OF SECTION 23 0549

SECTION 23 0593

TESTING, ADJUSTING AND BALANCING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 GENERAL

- A. Conform with applicable provisions of the General Provisions and the General Requirements.
- B. Testing, adjusting and balancing (TAB) shall be performed by a TAB Agency which is independent of the Mechanical Contractor.
- C. The TAB Agency's efforts shall be paid for by the Contractor and included in the mechanical contract price.
- D. Unless specifically noted, all work specified in this section shall be included in the scope of the TAB Agency's work. But some work described in this section is to be performed by the mechanical contractor, controls contractor, or others, and that work is specifically noted to be by these entities.

1.2 SCOPE

- A. Provide TAB for the systems and equipment installed under Division 23, including but not limited to:
 - 1. Supply and exhaust air systems including process and kitchen systems.
 - 2. Return air where specifically noted.
 - 3. Hydronic systems including domestic HW return systems.
- B. Provide all labor, instruments, and tools necessary to test, adjust and balance the systems shown on the drawings and/or described in these specifications. Check equipment performance, take measurements, adjust systems and equipment to provide specified performance, and report results. Submit reports to keep all parties posted on the progress of the TAB work.
- C. Where the TAB effort indicates deficiencies in system performance, TAB Contractor shall take the lead in a collaborative effort to trouble-shoot and resolve these deficiencies. Engage the assistance of others where necessary, starting with the Mechanical Contractor and Controls Subcontractor. Take additional measurements as required to identify the cause of the deficiencies, perform additional TAB as required to bring the system in compliance with the design intent. Engage the assistance of the Engineer and others where necessary. Indicate final setpoints and readings in a final TAB report.
- D. Include three days of effort on site for tests and/or balancing as directed in writing by the Owner's Representative beyond that described herein, but prior to substantial completion.
- E. Include two days on site for TAB efforts as directed in writing by the Owner's Representative after substantial completion.

1.3 STANDARDS AND DEFINITIONS

- A. Perform all work in accordance with these specifications and the latest edition of the NEBB Standards.
- B. Air Handling Unit: Where the term Air Handling Unit (AHU) is used in this spec section, it shall include any factory fabricated or field erected unit that includes a fan and other components which filter, heat, cool, humidify or dehumidify the air stream. But the term AHU, where used in this section, does not include fan powered terminal units, fan coil units, unit heaters, cabinet unit heaters, etc.
- C. Air Handling System: A fan or AHU and ductwork.
- D. Hydronic System: A system in which a liquid is used to convey heat.
- E. Record or Report: Where used as a verb, these terms mean to include in the TAB report.

1.4 QUALIFICATIONS

- A. TAB agencies shall meet the following qualifications:
 - 1. Membership in the Associated Air Balance Council (AABC), National Environmental Balance Bureau (NEBB) or the Testing, Adjusting and Balancing Bureau (TABB).
 - 2. An office located within a 100 mile radius of the project site.
 - 3. A minimum of five (5) years experience in the TAB field.

1.5 SUBMITTALS

- A. Mechanical Contractor shall submit the name of the proposed TAB agency prior to the TAB agency performing any services.
 - 1. Submit a list of proposed personnel, including resumes with related project experience and certifications.
 - 2. Submit proposed TAB procedures, instrumentation and measurement equipment including calibration data, and proposed sample TAB report forms.
- B. Pre-Construction Report: Prior to the Mechanical Contractor installing the systems, the TAB Agency shall submit a letter indicating whether the design includes all devices the TAB Agency will need to successfully perform the TAB work. If any additional balancing devices are needed, the TABB Agency shall so note this in the pre-construction report.
- C. Pre-Construction Test: Measure and report system air and water flows and equipment performance prior to any demolition or new construction work.
- D. Submit TAB reports as noted herein. Reports shall be in both hard copy and PDF format.

1.6 TAB PREPARATION AND COORDINATION

- A. Mechanical Contractor shall perform the following in a timely fashion:

1. Provide the TAB Agency with the project documentation (drawings, specifications, bulletins, submittals, shop drawings, etc.) necessary to perform the TAB services.
 2. Install, fill, pressure test, start up, clean, and the vent systems to be tested and balanced.
- B. Controls Subcontractor shall perform the following in a timely fashion:
1. Install and make operational all necessary control systems and equipment, including computers and computer programs.
 2. Provide qualified personnel to operate the systems as necessary to support the TAB effort. Provide the TAB contractor with the computer software necessary to facilitate the TAB effort.
 3. Assist as required to resolve problems which become evident due to TAB work, and as required to obtain specified system performance.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- A. Provide all equipment and instruments necessary to perform the work specified herein. Calibrate and maintain instruments per NEBB Standards. Provide not less than the following:
1. Pitot tubes and draft gauges.
 2. Flow hood.
 3. Velometer.
 4. Thermometers.
 5. Pressure gauges.
 6. Flow meter test kit.
 7. Ampere – voltmeter.
 8. Speed indicator.
 9. Sound meter to measure eight octave bands.

PART 3 - EXECUTION

3.1 GENERAL

- A. Review and inspect the mechanical systems for conformance with design documents. Test, adjust and balance all system flows under design conditions and under other conditions where part load testing is specified. Comply with measurement tolerances per NEBB. Balance to within 10% of design flows unless otherwise specified.
- B. Visually mark the final settings of balancing dampers, balancing valves, fan speed controls, etc.
- C. Comply with NEBB Standards. The descriptions included herein are a guide to the minimum information needed.
- D. Troubleshooting: In the event that any areas fail to get proper flow, take the lead in troubleshooting the system. Measure pressures, flows, etc. at various points throughout the systems as required to identify the cause of the deficiencies and identify upgrades which will

resolve these deficiencies. Coordinate any remedial efforts directly with mechanical and controls contractors and re-test as required.

3.2 TEST AND BALANCE REPORT

- A. Include a cover sheet with the project name and the names of the Mechanical Contractor and Engineer, table of contents, summary indicating the highlights of the report and summarizing any deficiencies and recommendations, summary of the test procedures used, names of the persons performing the tests, dates the tests were performed, list of instruments used along with their calibration data, and data sheets and drawings as indicated below.
- B. Report shall be 8-1/2" x 11" bound into a complete and coherent report, except that drawings may be larger size, but still bound into the report. All forms shall be typewritten or legibly handwritten.
- C. Submit five copies and a PDF of the complete TAB report minimum two weeks before the first O&M instruction session. One copy will be returned to the Contractor with review comments.

3.3 BASIC AIR HANDLING SYSTEM TESTING, ADJUSTING AND BALANCING

A. General

- 1. Test all fans and air handling systems. Balance systems to achieve specified air flows while minimizing throttling losses.
- 2. Air Flow Measurements: Fan and AHU flow rates may be determined by pitot tube traverse or by measuring fan speed, suction and discharge pressures, and comparison with the fan curve. Measure duct air flows using pitot tube traverses. Measure air flows of grilles, registers and diffusers using either capture hoods or pitot tube traverses in the connected ductwork. Make such other tests as may be required to demonstrate that systems perform per the design requirements.
- 3. Air Flow Measuring Stations: Calibrate each air flow measuring station which is provided as part of the construction contract. Use duct pitot tube traverses or other appropriate means to measure air flows. Coordinate with the flow measuring station supplier, and enter calibration coefficients into the FMS. Record the results of this effort.
- 4. Alert Mechanical Contractor and Engineer if any fan or air handling unit (AHU) appears to be operating in an improper or unsafe condition.
- 5. Seal all test holes in ductwork once testing is complete. Repair insulation jackets to maintain the integrity of the vapor barrier.
- 6. Include in the report copies of ductwork drawings with test points indicated.
- 7. Variable Flow Systems: Verify proper fan tracking from full flow to 50% flow.

B. Fans: Perform the following for all fans, including those provided as part of an AHU.

- 1. Fan Nameplate: Record unit number per the equipment schedule, manufacturer, model, size, and serial number.
- 2. Performance Data: Measure air flow and adjust fan speed to achieve required flow. Record air flow, static pressure rise and fan speed.

- a. Advise when belt and/or sheave changes are required to achieve the design flows. Mechanical contractor shall make the necessary changes as part of the mechanical contract. Approximately 25% of fans may require a sheave and/or belt change.
 3. Current and Voltage: Record motor nameplate and measured voltage and amperage. Advise if motor amps exceed rated load amps.
- C. Air Handling Units:
1. Outside Air: Test outside air flows using a pitot tube traverse and balance as required. If a traverse is not practical, use the mixed air temperature method if the inside and outside temperature difference is at least 20 deg F, or use the difference between pitot tube traverses of the supply and return air ducts.
 2. Static Pressure: Measure and record the static pressure at the inlet and outlet of each AHU component, including louvers, dampers, filters, coils, etc, and at each inlet and discharge duct connection.
- D. Coils: Measure and record air and water flows and pressure drops.
- E. Air Distribution Systems:
1. Zone, Branch and Main Ducts:
 - a. Adjust to within 10% of design air flows. Balance so that at least one zone balancing damper is wide open. Balance multi-diffuser branch ducts so that at least one outlet or inlet damper is wide open.
 2. Air Terminal Units:
 - a. Calibrate flow sensors and enter design maximum and minimum flow setpoints into FMS.
 - b. Record terminal unit number, size, specified flow, agency measured flow, FMS measured flow, and DDC flow correction factors.
 3. Diffusers, Registers and Grilles:
 - a. Test, adjust, and balance each diffuser, grille, and register to within 10% of specified design requirements. Record the size of each grille, diffuser, and register, initial flow measurement, and final measured flow.
 - b. Where rooms are indicated to be maintained at either positive or negative pressure, balance air flows to achieve these conditions under design flow conditions, and verify proper pressurization at minimum flow.
- F. Fan Coil Units, Unit Heaters, Cabinet Unit Heaters, Air Curtains, Door Fans, Fan Powered Terminal Units and other devices with fans and coils:

1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.
3. Measure and record initial and final water flows and pressure drops.

G. Duct Leakage Testing

1. Specification Section 23 3000 describes the requirements for duct leakage testing. Provide all instrumentation and labor to take the required measurements.
2. The Mechanical Contractor shall provide the fans and all other required work.
3. Submit test report. Retest until ductwork complies with specified leakage criteria.

3.4 HYDRONIC SYSTEMS

A. General:

1. Prior to commencing hydronic balance:
 - a. Set valves to proper position per the sequence of operation. Open all coil valves to full open position. Set 3-way valves to full flow through system component.
 - b. Check pump rotation.
 - c. Verify that system is adequately pressurized.
 - d. Set temperature controls so all system components deliver maximum flow.
 - e. Balancing may be done in sections.
2. Pumping Systems: Measure flows and determine operating characteristics of hydronic systems with pumps operating both independently and in parallel (where applicable). Make measurements at maximum flow.
3. Balance systems to minimize throttling out in the distribution, and to instead throttle at the pump discharge. Recommend impeller trimming if appropriate.
4. Measure and report performance readings on all pumps, coils, heat exchangers, heating and cooling water generating equipment, flow measurement devices, heat rejection equipment, etc. Measure and record the following for each item of hydronic equipment:

Eqpt Type		Pumps (Note 1)	Chillers	Air Cooled Condensers	Cooling Towers	Hot Water Boilers	Steam Boilers	Heat Exchangers	Coils			
Tag No.		X	X	X	X	X	X	X	X			
Nameplate Data	Mfgr	X	X	X	X	X	X	X	X			
	Model	X	X	X	X	X	X	X	X			
	Serial	X	X	X	X	X	X	X	X			
	Volts	X	X	X	X	X	X					
	RPM	X	X	X	X	X	X					
	HP	X			X							
	FLA	X	X	X	X	X	X					
	Refrigerant		X	X								
Scheduled	GPM1	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2		X					X				
	Press Drop		X					X				
Measured	GPM1	X	X		X	X		X	X			
	Inlet Press	X	X		X	X		X	X			
	Outlet Press	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2	X	X					X				
	Inlet Press	X	X					X				
	Outlet Press	X	X					X				
	Press Drop	X	X					X				
	Volts	X	X	X	X	X	X					
	Amps	X	X	X	X	X	X					

Notes

- 1 For pumps measure pressure rise instead of pressure drop. Measurements for GPM2 shall be at shutoff conditions.

3.5 LIMIT DEVICES AND SAFETY CONTROLS

- A. Limit Devices: Check all limit devices to verify proper operation, including, freezestats, flow switches, etc. Include in the TAB report a list of all such devices and the results of their tests.
- B. Fire and Smoke Dampers
1. Test each fire damper, smoke damper, and fire/smoke damper to ensure proper operation. Record test results.
 2. Fire Dampers: Open access door, disconnect fusible link or activate thermal link, and verify that damper closes smoothly and completely. Reset damper and access door.
 3. Smoke Dampers: Open access door, activate damper, observe whether it closes smoothly and completely, and measure closing time. Reset damper and verify it opens completely. Close access door and record test results.

- C. Life Safety Controls: Test and record life safety control operation of the HVAC systems. Verify the installation of required smoke detectors in air handling equipment, and verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown or other required functions as described on the control drawings and sequence of operation. With assistance from the contractors for mechanical, temperature controls and electrical work, verify the operation of interconnected systems, such as the smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequence.

3.6 SOUND TESTING

- A. Measure sound level in approximately ten percent of rooms as directed by Engineer.
 - 1. Shut off mechanical equipment and measure background sound level in each octave band.
 - 2. Start mechanical equipment and measure sound level in each octave band.
 - 3. Submit a plot of measured data against noise criteria (NC) curves.
- B. Where measured sound levels are deemed by Owner to be unacceptable, work with Engineer and Mechanical Contractor to reduce actual levels, and retest as required.

END OF SECTION 23 0593

SECTION 23 0700

MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 0504, Pipe and Pipe Fittings.
- C. Section 23 3000, Air Tempering System and Equipment.

1.3 SCOPE

- A. Field insulation of piping: see drawings and Part 3 of this specification.
- B. Field insulation of ductwork: See drawings, Table 23 0700-1, and Part 3 of this specification.
- C. Field insulation of equipment supplied and/or installed under Division 23: See drawings and Part 3 of this specification.
- D. Factory-insulated equipment and materials are described on the equipment schedule, on the drawings, and in other sections of this specification.

1.4 SUBMITTALS

- A. Submit products to be used including insulation, jackets, miscellaneous products, and products for special applications. Review each application and advise if any product is either not suitable for, or not recommended for the application.
- B. Verify that each submitted product meets all requirements for that product as specified herein. Include literature that clearly shows products meet all aspects of the spec. Include a cover sheet or letter with the following statement:

“Each product submitted here meets all specified requirements for that product except as follows:” followed by a list of any discrepancies.

- C. Submit schedules showing the type of product and thickness for each application. Indicate products to be used on valves and fittings. Indicate where vapor barriers will be provided and what jackets will be used.
- D. D-5, D-6 & D-7 insulation: If one of these insulations is specified, submit documentation

indicating that the submitted materials are approved for the intended service.

- E. Submit a description of the application techniques to be used.

1.5 QUALITY ASSURANCE

- A. Comply with the latest edition of the National Commercial & Industrial Insulation Standards, as published by the Midwest Insulation Contractors Association.
- B. Part 3 and Table 23 0700-1 give the system temperatures for various applications. Supplier shall review these temperatures and confirm the suitability of all components for the specified applications.
- C. Test piping and ductwork in accordance with applicable specification sections before insulation is applied.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials must be 100% asbestos-free and 100% formaldehyde-free, NO EXCEPTION.
- B. All materials must be GreenGuard Certified, GreenGuard Certified for Children and Schools.
- C. Smoke and Fire Ratings: All materials shall have a composite fire and smoke hazard rating not exceeding flame spread 25, fuel contribution 50, smoke developed 50, when tested as assemblies per ASTM Standard E-84 or NFPA 255.
- D. Thermal conductivities: Per ASTM C518. Do not exceed the conductivities indicated. Units listed herein for conductivity are Btuh-in/SF-F. Resistance shall not be less than the values specified herein. Units for resistance are SF-F/Btuh.
- E. Noise Reduction Coefficients: Per ASTM C423 based on Type A mounting. NRC shall not be less than as specified.
- F. Jackets: Maximum 0.02 perm water vapor transmission per ASTM E96 Procedure A.
 - 1. ASJ: All service jacket per ASTM C1136 Type I, paintable white kraft paper outer surface reinforced with glass fiber yarn and bonded to aluminum foil, with self-sealing longitudinal lap and butt strips, breach puncture min. 50 oz-in/in tear per ASTM D781, tensile strength min. 30 lb/in per ASTM D828.
 - 2. FSK: Foil skim kraft per ASTM C1136 Type II.
- G. Fiberglass insulation: Inorganic fibers bonded with thermosetting resin.
- H. Approved Manufacturers: Owens Corning, Johns Manville, Knauf, Certain-Teed, Kflex, Armacell, Unifrax -Insulfrax, Industrial Insulation Group, Pittsburgh Corning. Where the term OAE is used herein, this refers to these manufacturers only. No other manufacturers are approved for this project.

2.2 PIPE INSULATION

A. General

1. Valves, Fittings, and Accessories: Use the same insulation materials and thickness as the pipe insulation, except as noted.

B. Type P-1, Fiberglass Pipe Insulation: Factory assembled insulation and ASJ. Pre-formed fiberglass per ASTM C547 Type I, suitable for use on surfaces from 0–850°F, with thermal conductivity 0.23 at 75°F or 0.33 at 250°F, and minimum 3 pcf density. ASJ shall have self-sealing lap at end and along length, with pressure sensitive tape lap sealing system. Owens Corning SSL II Pipe Insulation, Johns Manville Micro-Lok, Knauf Pipe Insulation.

1. Where Type P-1 insulation is used, insulate fittings, valves and accessories using one of the following:
 - a. Fiberglass pre-formed fitting insulation complying with the specification for P-1 pipe insulation, Johns Manville Hi-Lo Temp insulation inserts, Hamfab, OAE. Finish with Type J-2 fitting covers.
 - b. Where pre-formed fitting insulation is not available, the following may be used: minimum 0.75 pcf density fiberglass per spec for D-1 insulation except without FSK. Finish with Type J-2 fitting covers or with two coats of fitting mastic with fiberglass fitting tape embedded between coats.

C. Type P-2, Fiberglass Pipe and Tank Insulation: Similar to Type P-1 insulation and jacket, except with fibers oriented to allow insulation to be wrapped onto curved surfaces, with conductivity 0.30 at 100°F, or 0.55 at 400°F. Johns Manville Pipe & Tank Insulation, Owens Corning Pipe and Tank Insulation or Knauf Pipe and Tank Insulation.

1. Alternate: Fiberglass board insulation similar to Type D2, scored for application on curved surfaces, with ASJ.

D. Type P-3, Calcium Silicate Pipe Insulation: Rigid calcium silicate per ASTM C533, Type 1, asbestos-free, suitable for use on piping up to 1200°F, conductivity 0.55 at 700°F, compressive strength min. 200 psi at 5% compression. Industrial Insulation Group OAE.

1. Fittings, valves and accessories: Insulate with mitered Type P-3 insulation or Type D-7 insulation.

E. Type P-4, Elastomeric Foam Pipe Insulation: Pre-formed elastomeric foam, ASTM C534 Type 1 flexible, closed cell, suitable for use up to 220°F, UV protected, not to exceed flame spread 25 and smoke developed 50 based on 0.75-inch thickness, conductivity 0.30 at 75°F. Kflex, Armacell OAE.

1. Fittings, valves and accessories: Insulate using either Type P-4 insulation pre-formed for use on fittings and valves, or cut sections of P-4 pipe insulation to match the shape of the fitting or valve, taped on using PVC tape.

2.3 DUCTWORK INSULATION

- A. Type D-1, Fiberglass Blanket: Factory fabricated insulation and FSK jacket assembly suitable for applications from 40-250°F, 3/4 pcf fiberglass, ASTM C553 Type I or II, with thermal resistance not less than the following for 2-inch thickness: 6.8 out of the box, 5.6 installed with 25% compression. Johns Manville Microlite XG Duct Wrap, Owens Corning Soft R Duct Wrap, Knauf Friendly Feel Duct Wrap, Certainteed Soft Touch Duct Wrap.
- B. Type D-2, Fiberglass Board: Similar to Type D-1 except rigid board type, 3 pcf density, thermal conductivity 0.23 at 75°F, NRC 1.36, suitable for unfaced side at up to 450°F and faced side at up to 150°F. Johns Manville 800 Series Spin Glas, Owens Corning 700 Series Board, Knauf Insulation Board, Certainteed Certra Pro Commercial Board
- C. Type D-3, Acoustic Lining (roll type): Organic fiber or fiberglass duct liner bonded with thermosetting resin, with factory-applied acrylic surface coating treated with anti-microbial agent, and factory-applied or shop-applied edge coating.
 - 1. Properties: Minimum 1.5 pcf density, thermal conductivity 0.24, 6000 FPM rated per UL 181, NRC 0.70 at 1-inch thick and .95 at 2-inch thick. The product (fiberglass, resin, coating, microbial agent and adhesive) as an assembly shall be suitable for surfaces and gases up to 250°F, and shall comply with ASTM C1071 (Type I), G21 and G22.
 - 2. Lining surface shall be cleanable using commercially available duct cleaning equipment when performed by qualified technicians using procedures established and recommended by the North American Insulation Manufacturer's Association (NAIMA) Duct Cleaning Guide.
 - 3. Johns Manville Linacoustic RC, Owens Corning Acoustic R duct liner, Knauf EM duct liner, Certainteed ToughGuard R Duct Liner.
- D. Type D-4, Acoustic Lining (board type): Similar to Type D-3 and complying with all aspects of the spec for Type D-3 insulation, except 3 pcf density rigid board with NRC 0.75 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Permacote Linacoustic R-300. Owens Corning Duct Liner Board, Knauf Rigid Plenum Liner, Certainteed Rigid Liner Board.
- E. Type D-5, Grease Duct Applications: High temperature, foil-encapsulated inorganic blanket, 8 pcf. Insulfrax Fyre Wrap Max 2.0, Johns Manville Fire Temp, OAE. Product shall meet the following when applied as 2-layers around a grease-duct:
 - 1. Tested and listed for zero clearance to combustibles across the entire surface of the blanket material per internal fire test AC101 or ASTM E2336 - Internal Fire Test – 2 Hr Grease Duct Enclosures.
 - 2. Rated as a 2-hr fire resistive enclosure assembly per ASTM E-119, Engulfment Fire Test for 2-hr Grease Duct Enclosure.
- F. Type D-6 –Combustible Materials within Plenum: For use on combustible materials located within supply or return air plenums, foil-encapsulated 8 pcf high-temperature ceramic fiber blanket suitable for service up to 1800°F. Unifrax Fyre-Wrap 0.5 plenum insulation.
- G. Type D-7 – Fire Rated Ductwork: Suitable for continuous operation at 1800°F, 6-pcf, foil-encapsulated inorganic blanket to provide a 2-hour rating per ISO 6944 when applied in a single 1.5-inch thick layer. Insulfrax FyreWrap 1.5 OAE.

- H. Type D-8 – Polystyrene Insulation: Rigid cellular square edge insulation per ASTM C578, waterproof, thermal conductivity 0.20, compressive strength 25 psi. Dow Styrofoam or Owens Corning Foamular.
- I. Type D-9 – Fiberglass Ductboard: Listed per UL 181 as a Class 1 Rigid Air Duct; conforming to ASHRAE Std. 62, NFPA-90A and 90B, ASTM G-21 & G-22; rated for 2-in. wg; constructed of fiberglass bonded with a thermosetting resin, with double density slip joints pre-molded in the board; FSK jacket; thermosetting acrylic polymer interior surface, and black interior surface color. Thermal conductivity 0.23, and NRC 0.70 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Superduct 475 or 800, Owens Corning Quiet R Duct Board, Knauf Duct Board M, Certainteed ToughGard Duct Board

2.4 EQUIPMENT INSULATION

- A. E-1, Removable Insulating Blanket: Factory fabricated, one-piece, removable and re-usable insulating blanket with fiberglass insulation completely enclosed within a silicone coated fiberglass cloth with draw cords of SS or PTFE coated glass fiber, and stainless steel clips. Insulation thickness shall be as specified elsewhere, but not less than 1-inch. Energy Systems Inc. “Q-Master” OAE.

2.5 INSULATION JACKETS

- A. Type J-1, Metal Jacket: 0.010-inch smooth Type 304 stainless steel or 0.016-inch smooth or embossed aluminum per ASTM B-209, with minimum 1-mil polyethylene film with protective layer of 40 Lb virgin kraft paper, continuously laminated to full width inside jacket. Childers OAE.
 - 1. Where jacket diameter is 16–96 in: 0.016-in. SS or 0.020 in. aluminum.
 - 2. Equipment heads and all surfaces where jacket is greater than 96-inch OD: 0.020-inch SS or 0.024 inch aluminum.
 - 3. Fittings and Accessories: Provide the same jacket material as for pipe.
- B. Type J-2, PVC Jacket: Minimum 20 mil sheets and 30-mil pre-molded fitting covers, ASTM D1784, Class 16354-C. Accessories include solvent weld solution, stainless steel tacks, and tape. All components shall be white, UV resistant, with paintable exterior surface, and suitable for use at –20 to +150°F. Johns Manville System 2000 (sheets), Zeston 300 (fitting covers), and Perma-Weld (solvent cement), OAE.
- C. Type J-3, Canvas Jacket: 10 x 10 fiberglass mesh.

2.6 MISCELLANEOUS PRODUCTS

- A. General:
 - 1. Tapes: Aluminum, pressure sensitive, UL 181A-P listed and embossed, minimum 2.5-inch wide, Nashua 324A OAE.
 - 2. Duct Liner Adhesives: Water-based, complying with ASTM C916.
 - 3. Solvent Cement for PVC Jackets: Johns Manville Perma-Weld OAE.
 - 4. Staples: Outward clinching, 0.5-inch galvanized steel

B. Piping Systems:

1. Pipe Hanger Insulation Inserts: Mechanical Pipe Shields Inc. "Snapp Itz" OAE.

C. Ductwork Systems:

1. Duct Liner Edge Sealer, Surface Sealer, Coatings & Adhesives: To meet ASTM C916. Johns Manville Superseal OAE.

PART 3 - EXECUTION

3.1 GENERAL

- A. Delivery, Storage and Handling: Deliver and store insulation materials in factory-supplied containers. Protect from moisture. Do not install any materials that have gotten wet, regardless whether they are subsequently dried.
- B. Store and apply materials in accordance with manufacturers' recommendations, but not less than the following minimum temperatures. Ensure surfaces are clean and dry prior to application, and for minimum two hours after application:
 1. Sealers, coatings, solvents and adhesives: 40°F.
 2. Tapes 50°F.
- C. Install in accordance with manufacturer's recommendations, NAIMA recommendations, and this spec. Provide good ventilation.
- D. Where vapor barriers are specified, ensure that the entire system is vapor sealed.
- E. Protect materials from water damage. Replace any materials that are water-damaged prior to substantial completion.

3.2 PIPING INSULATION

- A. General: Insulate piping as indicated herein and/or on the drawings. Except as noted, insulate all valves, fittings, and accessories with the same material and thickness specified for the pipe. Where piping is specified with a separate insulation jacket provide this same jacket for valves, fittings and accessories. Vapor seal cold piping systems.
 1. Where insulation terminates, provide insulating cement beveled for a neat finish. For vaposealed piping, coat with insulating mastic prior to applying insulating cement.
 2. Strainers and Suction Diffusers: Either Type P-1 or P-3 insulation. Make provisions to easily remove and re-install insulation.
 3. Pipe Supports: Provide high density calcium silicate insulation or insulation inserts as specified. Maintain pipe jacket and vapor barrier at supports. If necessary, apply a heavy coating of vapor barrier mastic material to prevent condensation from forming on supports. Provide galvanized steel insulation shields to protect insulation and jackets at supports.
 4. Penetrations Through Building Construction: Insulation shall be continuous where

piping passes through walls, floors, and other construction. Where insulated piping passes through fire and/or smoke rated construction, provide a section of UL approved fire safing insulation to match the required insulation thickness, or provide an insulated pipe sleeve as manufactured by Pipe Shield, Inc., OAE.

5. Mechanical Couplings: Where mechanical couplings are permitted, insulate them as specified for fittings.
6. Steam Traps: Do not insulate.
7. Retrofit Projects: Match the thickness of existing insulation where new insulation adjoins existing. Integrate new vapor barrier with existing so the insulation barrier is continuous for both new and existing piping.
8. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

B. Application:

Temp Range	Temp (F)	Insulation Type	Vapor Sealed	Pipe Size				
				Under 1	1 - 1.5	Over 2 - 3	4 & 6	8 & Larger
TR-1	60&Less	P-1 or P-4	Yes	1.5	1.5	1.5	1.5	1.5
TR-2	61 – 104	P-1	Yes	0.5	0.5	0.5	0.5	0.5
TR-3	105 - 140	P-1	No	1.0	1.0	1.0	1.0	1.0
TR-4	141 - 200	P-1	No	1.5	1.5	2.0	2.0	2.0

1. Temperature Range TR-1: Chilled water, refrigerant suction, condenser water (outdoor piping subject to freezing).
2. Temperature Range TR-2: Domestic cold water, makeup water, soft water, industrial water, process water of any type, non-potable water, HVAC make-up water (except insulation is not required for evap cooler makeup piping outdoors), interior horizontal roof drain and overflow bowls and piping, condensate drains indoors.
3. Temperature Range TR-3: Domestic hot water (including non-circulating HW within interior walls and chases) and domestic HW return except as noted.]
4. Temperature Range TR-4: [Heating water supply and return, low pressure steam condensate, pumped condensate return, engine cooling water.

- C. Type P-1 & P-2, Fiberglass Insulation: Install in accordance with manufacturer's recommendations.
- D. Type P-3, Calcium Silicate Insulation: Adhere to pipe or equipment using stainless steel wire. Provide removable J-1 jacket.
- E. Type P-4, Elastomeric Foam: Seal all butt ends and longitudinal joints with Halstead Adhesive. When exposed to the weather, protect flexible tubing insulation with two coats of exterior weatherproof coating as recommended by manufacturer.
- F. Jacketing: In addition to the finish and jacket specified for the particular type of insulation, provide the following:

1. Indoor piping exposed to physical damage Type J-2, PVC

- | | | |
|----|---|-----------------|
| 2. | Mechanical Eqpt Spaces: Exposed piping
less than 8 ft above floor or operator platform | Type J-2, PVC |
| 3. | Exterior piping | Type J-1, Metal |

3.3 DUCTWORK INSULATION

A. General:

1. Insulate all ducts except those specified to be uninsulated. The following ductwork need not be field insulated:
 - a. Factory insulated ductwork and plenums.
 - b. Ducts with acoustic lining, provided the lining thickness matches or exceeds the required insulation thickness.
 - c. Exhaust ducts, except where noted.
 - d. Return air ducts, except where noted.
2. See Table 23 0700-1 for additional information.
3. Ensure that ductwork is leakage tested prior to applying insulation. Inspect ductwork and repair any deficiencies prior to applying insulation. Do not apply insulation over deficient ductwork or plenum construction.
4. Ensure that ductwork is clean and dry before applying insulation.
5. For ductwork with acoustic lining the drawings indicate the "clear inside duct dimension" required. Over-size ducts as required to provide the required air flow area.

B. Type D-1, Fiberglass Blanket Insulation: Measure and cut insulation. Install so insulation is not excessively compressed at corners. For rectangular and flat oval ducts 24-inches and wider, provide stick pins and speed clip washers 18-inches on centers on the bottom, and clip off excess length of stick. Firmly butt insulation ends and longitudinal joints. Overlap jacket minimum 2-inches at end joints and longitudinal joints, staple on 6-inch centers, and continuously seal jacket. Provide vapor barrier mastic where ducts are indicated to be vaporesealed. Should gaps or fishmouths occur, re-staple and seal them with mastic. Use FSK tape and vapor barrier mastic to seal all penetrations of the FSK jacket, such as pins, tears, and hangers. Neatly trim and seal insulation at access doors, ends, damper rod controls etc. Verify proper damper operation.

C. Type D-2, Fiberglass Board Insulation: Attach with mechanical fasteners 12" on centers.

D. Type D-3 & D4, Acoustic Lining: Ductwork dimensions indicated on the drawings are net air flow dimensions inside liner. Increase duct size to accommodate liner. Completely line the inside surfaces of ducts and plenums specified and indicated. Comply with the NAIMA Fibrous Glass Duct Liner Standard (FGDLS), manufacturer's recommendations, and this spec. Adhere liner with minimum 90% coverage of adhesive, and secure with mechanical fasteners and washers per FGDLS and manufacturer's recommendations. Fastener length shall be sufficient to limit compression of liner to 1/8" maximum. Coat all cut edges and surface penetrations with edge sealer. Provide metal nosing for liner leading edges at fan discharge and for all ducts with air velocities exceeding 3,000 FPM. Maintain minimum 18-inch clearance from electric resistance heaters. Interrupt liner at dampers and apply external insulation at these locations.

1. Provide Type D-3 insulation for the 10 feet upstream of roof exhaust fans except in wet air streams.
- E. Type D-5: Install insulation in a 2-layer system per manufacturer's instructions, including the use of mechanical fasteners for the underside of ducts, butting or overlapping of joints, and offsetting of joints on outer layer.
- F. Type D-6: Install in accordance with manufacturer's instructions. Overlap seams and joints minimum 2-inches, affix with SS wire minimum 18-inches on centers, but not less than per manufacturer's recommendations, and tape seams and joints with aluminum tape.
- G. Type D-7: Install insulation in a single-layer system per manufacturer's instructions. Mechanical fasteners for the underside of ducts shall be adhered to the duct in a manner suitable for the operating temperatures (welded or other suitable method). Butt or overlap joints per manufacturer's recommendations.
- H. Type D-8: Wire in place with SS wire minimum 12-inches on centers, and provide J-1 jacket.
- I. Type D-9: Install per manufacturer's recommendations, NAIMA standards, and SMACNA Fibrous Glass Duct Construction Standards. Provide ship lap seams and joints.

3.4 JACKETING

- A. Type J-1, Metal Jacketing:
 1. Ducts: Slope jacketing to shed rain.
 2. Pipes: Install with seams at the 3 o'clock or 9 o'clock position to shed water. Band 12" on centers.
 3. Joints and Seams: Overlap joints minimum 2-inches. Caulk with a weatherproof caulk when located outdoors.
- B. Type J-2, PVC Jacketing: Secure in place with tacks and solvent welded joints. White PVC tape may be used indoors.
- C. Type J-3, Canvas Jacket: Apply mastic at a rate of 60 to 70 sq. ft. per gallon, embed fiberglass mesh, smooth all wrinkles and apply finish coat of Sealfas, or equivalent.

END OF SECTION 23 0700

TABLE 23 0700-1 – DUCTWORK INSULATION

Service	Location	Condition	Insulation Type	Insulation Thickness (in)	Notes
Supply Air, Makeup Air, Outside Air	Indoor	Concealed	D1	1.5	1, 6
Supply Air, Makeup Air, Outside Air	Indoor	Exposed	D2	1.5	
Supply Air, Makeup Air, Return Air	Outdoor	All	D8	2	2, 4, 7
Supply Rectangular Ductwork downstream of Terminal Units, Fan Coil Units, Heat Pumps, Blower Coils and Low Velocity AHU's	Indoor	All	D1	1.5	1, 3
Return Rectangular Ductwork upstream of Fan Coil Units, Heat Pumps, Blower Coils and Low Velocity AHU's	All	All	D1	1.5	1, 3
Ductwork indicated to be lined	All	All	D3	1	5
Ductwork indicated to be lined with 2-inch acoustic lining	All	All	D3 or D4	2	5
Single Wall Lined Plenums	All	All	D4	2	
Transfer Air Ducts	All	All	D3 or D9	1	
Exhaust Ductwork	Indoor	Concealed	D1	1.5	8
Exhaust Ductwork	Indoor	Exposed	D2	1.5	8

Notes:

- 1 Includes Supply Air Duct from Energy Recovery Units and Evaporative Coolers.
- 2 Provide acoustical liner as indicated on the drawings.
- 3 Delete Type D1 insulation if acoustical liner is indicated by plan notes or shown on the drawings.
- 4 Provide J1 Jacket.
- 5 In hospitals do not provide acoustical lining in supply ductwork or plenums downstream of the final filter.
- 6 Vaporseal ducts conveying cold air.
- 7 Seal outdoor ductwork to prevent ingress of moisture.
- 8 Insulate only the portion of exhaust ductwork between isolation damper and outside.

SECTION 23 0900

FACILITY MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. The entire Facility Management System (FMS) specified hereafter shall be approved and listed by Underwriters' Laboratories, Inc., under UL 864 (Energy Management and Control System).

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 0505, Piping Specialties.
- C. Section 23 0523, Valves.
- D. Section 23 0549, HVAC and Electrical Installation Coordination.
- E. Section 23 0550, Variable Frequency Drives.
- F. Section 23 0593, Testing, Adjusting and Balancing.

1.3 SCOPE

- A. It is the intent of this Section to provide, install, connect, and calibrate the entire Facility Management System (FMS) as indicated on the Drawings and as necessary to provide fully automatic control for all systems as shown in the control drawings, stated in the sequences of operation, indicated in the electrical ladder diagrams, or as otherwise indicated in the Contract Documents. Some equipment controls may be specified to be provided in the Contract Documents outside this Section. As work of this Section, the Contractor shall coordinate with these other suppliers and trades to provide a completely integrated control system.
- B. It is the responsibility of the bidder to read and conform to all sections of the Specifications, review all Contract Drawings of all Divisions, and coordinate with all equipment suppliers of material specified under other sections of the Specifications including any Owner-furnished equipment.
 - 1. The engineering, installation supervision, programming, graphics development, calibration, startup, and checkout necessary for a complete and fully operational control system as specified hereafter shall be provided under this Section.
- C. Provide startup documentation verifying proper operation of all points and all integrated systems.
- D. Provide training and instruction of the installed control system.

1.4 PRIOR APPROVAL

- A. Prior approvals are not required. Facility Management System suppliers will be authorized factory representatives or branch offices of Johnson Controls.

1.5 SUBMITTALS

- A. Within thirty (30) days of contract award, submit sets of shop drawings and submittal data in accordance with Section 23 0500 and the General Contract Requirements. These submittals shall be delivered first to the mechanical and electrical sub-contractors for coordination review and evaluation prior to being submitted for final review. Letters from these sub-contractors verifying that they have reviewed the submittals, and any comments regarding the submittals, must be attached as part of the final submittal.
- B. Submittals shall consist of shop drawings, catalog data sheets, and point verification forms as defined in the following paragraphs.
 - 1. Shop drawings shall be provided which show all control devices, electrical ladder diagrams, control system schematics, sequences of operation, and a material list. All systems and the associated control components, as well as all connections between components, shall be clearly indicated. The submittal shall clearly indicate the required coordination with equipment supplied by others, including any Owner-furnished equipment. Simply showing a connection with no identification or termination will be considered unacceptable. All connections shown on the Drawings shall be labeled on both ends and these same labels shall be used for the installation process for ease of comparing the shop drawings to the actual field installation. Each control component shall be given a unique identifier. This identifier shall be used in the sequence of operation so that reference to the Drawings can be easily made. A complete FMS communication and power architecture drawing shall also be included on the shop drawing.
 - a. Electrical ladder diagrams shall be shown on the shop drawings. Electrical ladder diagrams shall show all switches, relays, motor starters, etc. The electrical ladder diagrams shall show the correct control wiring and interlock wiring of all equipment provided under the Contract including any Owner-furnished equipment. Each diagram shall reference the correct power source by breaker panel and circuit number or from a control transformer. If equipment shown is provided by another Contractor, then this shall be noted.
 - b. The sequence of operation for each controlled system shall be provided with reference to the control device identifier. The sequence of operation shall break down the control operation by major function (i.e., mixed air control, occupied-unoccupied, smoke purge, etc.) and describe in detail the correct operation and interaction with other system functions. Use of the sequence of operation stated on the Drawings is acceptable; however, it shall be modified to reflect actual control device identifiers.

- c. A complete material listing shall be included on the shop drawings which show the device model numbers, device identifiers, quantities, manufacturers, etc., of all equipment provided under this Section. The material list shall be organized in alphabetical order so that it can be easily compared to the associated catalog data sheets. The quantities are to be provided only to confirm a general understanding of the contract requirements and will not be verified as a complete material list.
 2. Catalog data sheets will be provided for each different piece of equipment provided under this Section. At a minimum the data sheet shall contain sufficient information so that compliance with the Specification can be verified. Where multiple models or options are indicated on the same catalog data sheet, the equipment proposed shall be highlighted or otherwise indicated. The catalog data sheets shall be organized in alphabetical order to match the material listing on the shop drawings.
 3. Point verification forms shall be completed for all points that will be installed as part of the FMS. Once approved, these forms shall be used during the testing and startup portions of this work. A template point verification form is located at the end of this Section.
- C. All re-submittals shall contain a cover letter restating all of the previous submittal comments made by the reviewing engineer along with a written statement by the Contractor as to the resolution of each item. Any re-submittal issued to the engineer without this cover letter will result in an automatic rejection of the submittal.

1.6 RECORD DRAWINGS

- A. Record drawings shall be provided as required by Section 23 0500 and the General Contract Requirements. Record drawings shall not be completed until after installation is complete. Any changes made during installation shall be recorded on the approved shop drawings as they are made so that a current record drawing is constantly being updated. These as-constructed drawings shall be available at all time for inspection by the Owner's Representative. At completion of the project, all manual changes shall be incorporated into a clean reproducible set of as constructed drawings. These as-constructed drawings shall be available for use during the training sessions.
- B. With the reproducible record drawings the Contractor shall furnish a complete spare parts lists, operating instructions, and maintenance literature, for proper maintenance of all control equipment, in accordance with the requirement specified in Section 23 0500.
- C. In addition to the record drawings, the following documents and manuals will be delivered to the Owner. Two (2) sets of these documents will be provided prior to training begins:
 1. At least one operating manual for each component purchased through a third party vendor including equipment such as computers, printers, video monitors, interface cards, modems, etc.
 2. All manuals relating to operating system software. This requirement includes not only the FMS operating software but also DOS, Windows, etc.
 3. A systems programmer's manual which will include all information necessary to perform FMS programming and produce system graphics.

- D. After final occupancy and all debugging have occurred, the Contractor shall prepare two (2) copies of all control software on non-volatile magnetic media and deliver them to the Owner.

1.7 SYSTEM TESTING

- A. The operation and accuracy of each component of the FMS shall be demonstrated to the satisfaction of the Engineer. This review shall include an operational evaluation of all stated sequences of operation (verified through the use of trend/graph results), electrical interlocks, safety devices, and final as-constructed drawings. Training shall not occur until the testing is complete and a report stating such has been accepted by the Owner's Representative.
- B. At the termination of the testing period, the Contractor shall provide completed point verification sheets for each point in the FMS. These sheets shall be included as a part of the closeout notebook described in Section 23 0900-3.3-7. An example of a point verification form is included in Appendix C.
- C. Trend logs and graphs shall be developed as described in Section 23 0900, 3.3 - 7 and Appendices A and B. Completed trend requirements shall be compiled into organized notebook(s) and delivered to the Engineer for approval before the final inspection and close-out of the project is performed.
- D. The Owner reserves the right to participate in or assign a representative to participate in the startup, testing, programming, or any other aspect of the construction of this project at no additional cost to the Owner.

1.8 TRAINING

- A. Upon completion of the work, provide 8 hours total of on-site instruction to the Owner's operating personnel who have responsibility for the mechanical system. A complete operating booklet shall be provided and used during the training period. The booklet shall include the as-constructed drawings as stated previously.

1.9 SERVICE AND WARRANTY

- A. The system supplier shall maintain a local maintenance support facility complete with system technicians, diagnostic and test equipment, and new spare components. Emergency service shall be available in the local office on a 24-hour, 7-day a week basis. The service agent shall provide a continuously monitored local service telephone number for emergency service and this number shall be provided to the Owner.
- B. Service and maintenance must be provided for one (1) year from the time of Owner's acceptance of the control system. Service during this period shall be available within 12-hours from the time the trouble call is placed. Warranty shall be for all materials and labor provided as the Scope of Work of this Section.

1.10 PROGRESS PAYMENTS

- A. When developing a schedule of values for the FMS and control systems, a minimum of 20% shall be reserved for activities after construction completion, including commissioning support,

testing (functional performance testing and trend logs as required herein), record drawings, training, etc. Payment for these activities may be requested as they are completed.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All products required for this project shall be selected in accordance with this part of the Section. Installation of the components shall be in accordance with Part 3 of the Section. If a component is required to meet the requirements shown on the Drawings and is not specified in the Part of the Specification, the supplier shall select and submit on components that meets all design requirements indicated on the Drawings, stated in the sequence of operation, and elsewhere in the Contract Documents.

2.2 PRIMARY OPERATOR WORKSTATIONS

- A. No new primary operator workstation is required as part of this project. The existing primary operator workstation[s] will be used for operator interaction. All new controllers shall be connected to the existing FMS network for connection to the primary operator workstation.

2.3 FMS CONTROLLERS

A. General

1. Standalone FMS controllers shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone FMS controller shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules, volatile and non-volatile memory, signal conditioners, etc.
2. The FMS controllers shall have UL-916 or equivalent CSA or ETL listings. The FMS/FMS field modules shall also conform to FCC Docket 20780, Part 15, Subparagraph B.

B. Hardware Requirements

1. Communications

- a. Each FMS Controller shall be equipped with the necessary hardware to permit connection to the FMS local area network described in this Section. All communications hardware shall be part of the standard manufactured product and no intermediary devices to establish communications shall be permitted.

2. Memory

- a. Each FMS Controller shall have sufficient memory to support its own operating system and databases including:

- Control processes.
 - Energy management applications.
 - Alarm management.
 - Historical/trend data for all points.
 - Maintenance support applications.
 - Custom processes.
 - Operator I/O.
 - Dial-up communications.
 - Manual override monitoring.
- b. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
- c. Should FMS controller memory be lost for any reason, the panel will automatically receive a download via the local area network, phone lines, or connected computer. In addition, the user shall have the capability of reloading the FMS controller via the local area network, via the local RS-232C port, or via telephone line dial-in.
3. Input/Output
- a. Each FMS controller shall support inputs and outputs of the following types:
- Type C digital inputs.
 - SPDT digital outputs.
 - Universal analog inputs which support all industry standard signals including 4-20 mA, 0-20 ma, 0-10 VDC, etc.
 - Universal analog outputs which support all industry standard signals including 4-20 ma, 0-20 ma, 0-10 VDC, etc.
 - Pulse Type C digital inputs.
 - SPDT pulsed digital outputs.
4. Communication Ports
- a. FMS controllers shall provide at least one RS-232C serial data communication ports for simultaneous direct connection of operator I/O devices including portable operator terminals (future) and printers. FMS controller shall allow connection to the serial ports without interrupting the normal operation of permanently connected modems, printers, or network terminals.
5. Override Switches
- a. Onboard hand/off/auto operator override switches shall be provided integral to the FMS controller for digital output points and positioning switches for all analog output points. The FMS controllers shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

6. Status Indicators

- a. The FMS controller shall have local status indication for each binary input and output without the need for an operator I/O device.

7. Surge and Transient Protection

- a. Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980.

8. Expandability

- a. The system shall be modular in nature, and shall permit expansion through the addition of workstation hardware, FMS controllers, sensors, and actuators.

9. On-Line Diagnostics

- a. Each FMS controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of onboard electronics. The FMS controller shall provide both local and remote enunciation of any detected component failures or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each FMS controller, and shall not require the connection of an operator I/O device.

10. Power Failure Restart

- a. In the event of the loss of normal power, there shall be an orderly shutdown of all standalone FMS controllers to prevent the loss of database or operating system software. Upon restoration of normal power, the FMS controller shall automatically resume full operation without manual intervention.

C. Software Requirements

1. General

- a. All necessary software to form a complete operating system as described in this Specification.
- b. All software routines and programs specified in this Section shall be provided as an integral part of the FMS controller and shall not be dependent upon any higher level computer for execution.

2. PID Control

- a. The FMS controllers shall perform full proportional, integral, derivative (PID) control with all PID loops having the automatic control loop tuning feature.

3. Minimum Runtimes

- a. The control software shall include a provision for all digital outputs to have minimum on/off cycle filters.
4. Staggered Starts
 - a. The control software shall include a provision for all digital outputs to electrical demand base start filters to prevent excessive electrical demand on the startup of equipment.
5. Automatic Restart
 - a. After an interruption of normal power, the FMS controller shall analyze the status of all controlled equipment, compare it with the commanded position and return all equipment ON or OFF as necessary to resume normal operation.
6. Energy Management Applications
 - a. The FMS controllers shall have the ability to perform all of the following energy management routines as standard sub-routines which do not require the application of customized software:
 - Time of day scheduling.
 - Calendar-based scheduling.
 - Holiday scheduling.
 - Temporary schedule overrides.
 - Optimal start.
 - Optimal stop.
 - Night setback control.
 - Enthalpy switchover (Economizer).
 - Peak demand limiting.
 - Temperature compensated duty cycling.
 - Chiller sequencing.
 - b. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. Programs shall be applied to building equipment as described in the Sequence of Operation.

D. Custom Programming

1. The FMS controllers shall be able to execute custom, job-specific processes defined by the operator, to automatically perform calculations and special control routines.
2. There shall be no restriction as to the ability of the operator to create any type of control logic using system inputs, calculated variables, Boolean Logic, etc.
3. The software shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified primary operator station or printer, buffer the information in a follow-up file, or cause the

execution of a dial-up connection to a remote operator workstation.

E. Alarm Management

1. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each FMS controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the FMS controller's ability to report alarms be affected by either operator activity at an Operator Workstation or local I/O device, or communications with other panels on the network.
2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three (3) priority levels shall be provided. Each FMS controller shall automatically inhibit the reporting of selected alarms during system shutdown and startup. Users shall have the ability to manually inhibit alarm reporting for each point.
3. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.
4. Each FMS controller shall be capable of storing a library of at least 250 alarm messages. Each message may be assignable to any number of points in the panel.

F. Report Routing

1. Alarm reports, messages, and files will be directed to a user-defined list of devices or disk files used for archiving alarm information.

G. Operator Log

1. Operator commands and system events shall be automatically logged to disk in personal computer industry standard database format. Operator commands initiated from direct-connected workstations, dial-up workstations, and local FMS controller network terminal devices shall all be logged to this transaction file. This data shall be available at the Operator Workstation. In addition, this transaction file shall be accessible with standard third party database and spreadsheet packages. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

H. Trend Analysis

1. The FMS controllers shall be capable of storing point history files for every analog and binary input and output at the same time. The point history routine shall continuously and automatically sample the value of all analog inputs at user definable intervals.
2. The FMS controllers shall also provide high resolution sampling capability in one-second increments for verification of control loop performance.
3. Trend data for the FMS controller as well as all associated ASCs and TCUs shall be stored at the FMS controllers, and uploaded to hard disk storage at the operator workstation when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be

available in disk file format compatible with third party personal computer applications.

I. Runtime Totalization

1. The FMS controllers shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this Specification.
2. The totalization routine shall have a sampling resolution of one (1) minute or less.
3. The user shall have the ability to define a warning limit for runtime totalization. Unique, user-specified messages shall be generated when the limit is reached.
4. The FMS controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

J. Event Totalization

1. Standalone FMS controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.
2. The event totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.4 APPLICATION SPECIFIC CONTROLLERS

- A. Each FMS controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASC). The ASC shall be selected to match the function required. In no case shall multiple ASCs be used for one piece of mechanical hardware or an entire system (HW or CW system) in an effort to increase point or memory capacity. If one ASC is unable perform all aspects of monitoring or control for any given piece of equipment or system, a FMS controller or more applicable ASC shall be applied.
- B. Each ASC shall operate as a standalone controller on a sub-LAN and shall be capable of performing its specified control responsibilities independently of other controllers on the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
- C. Each ASC shall have sufficient memory to support its own operating system and data bases for control routines, energy management applications, and operator I/O points.
- D. The operator interface to any ASC point data or programs shall be through an operator workstation or from a portable operators terminal.
- E. Power failure protection for all system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

2.5 TERMINAL UNIT CONTROLLER

- A. A Terminal Unit Controller (TUC) shall be provided for each terminal unit as indicated on the Drawings and as listed in the equipment schedule. The TUCs shall be connected as part of a LAN or sub-LAN which shall communicate at not less than 9600 Baud. Each terminal unit controller shall communicate on a peer-to-peer basis with all units having equal authority. Provide a TUC space temperature sensor for each TUC.
- B. Each TUC shall execute application programs, calculations, and commands via a microcomputer resident on the TUC. The database and all application programs for each TUC shall be stored in readable/writeable non-volatile memory within the TUC.
- C. Each TUC shall contain both software and hardware to perform full DDC/PID control loops. TUCs shall be able to provide analog output, in addition to normal binary type output.
- D. Each TUC shall be able to support various types of zone temperature sensors, including temperature sensor only, temperature sensor with built-in local override switch, with setpoint adjustment switch.
- E. Each TUC for VAV application shall have built-in air flow transducer for accurate airflow measurement of the cold duct airflow in order to provide the pressure independent VAV operation.
- F. Each TUC shall have a built-in detection circuit to monitor the presence of the power to the equipment, and in case of the absence of the power it shall generate an alarm to the Operator Workstation.
- G. Each TUC shall have LED indication for visual status of communication, power, and all outputs. All circuits shall be optically isolated.

2.6 OPERATOR INTERFACE PANELS

- A. The operator interface panel shall be a permanently mounted LCD display with keypad or touchscreen system. The LCD shall have a minimum of 80 characters on multiple lines. The operator interface panel shall connect directly to the FMS controller LAN or controller. Portable handheld devices shall not be approved.
- B. The operator interface shall allow the operator to perform commands within any FMS controller on the FMS local area network including, but not limited to, the following:
 - Startup or shutdown selected equipment.
 - Adjust setpoints.
 - Add/modify/delete schedules.
 - Enable/disable process execution.
 - Acknowledge alarms.
 - Enable/disable totalization for each point.
 - Enter temporary override schedules.

- Define holiday schedules.
- Change time/date.
- Enter/modify analog alarm limits.
- Enter/modify analog warning limits.
- View limits.
- Change password protection.

2.7 NETWORKING/COMMUNICATIONS

A. Primary Local Area Network (LAN)

1. A complete ETHERNET® communication network is installed throughout the facility and is operational in each building.
2. The only FMS equipment connections to the primary LAN are the FMS controllers or routers and the operator workstations. All other FMS hardware shall reside on either the Controller LAN or the sub-controller LAN.
3. All FMS devices that reside on the primary LAN shall be compatible with the ETHERNET®.

B. FMS Controller Network (LAN)

1. FMS controllers (if not on the primary LAN) and application specific controllers Interfaces within a specific building shall reside on the second tier LAN referred to as the controller LAN. The controller LAN shall begin at the building FMS controller or router and extend to one or more FMS controller LAN controllers located throughout the building.
2. Access to system data shall not be restricted by the hardware configuration of the network. The hardware configuration of the network shall be transparent to the user when accessing data or developing control programs.
3. Expansion of the network shall support any combination of FMS controllers.
4. The network shall include provisions for automatically re-configuring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures. The local area network shall also provide for error detection, correction, and re-transmission to guarantee data integrity.
5. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading at speeds no less than 9600 bps. No collision-based network shall be accepted below 10 Mbps.
6. Automatic synchronization of the real-time clocks in all FMS controllers shall be provided.
7. Expansion of the controller LAN is work provided entirely under this Section of the Specification.

C. Sub-Controller Local Area Network

1. All lower level controllers associated with terminal unit controllers shall reside on the third tier LAN referred to as the sub-controller LAN.

2. The sub-controller LAN shall operate RS-485 at a selectable speed of 9.6K or higher. Expansion of the sub-controller LAN is work provided entirely under this Section of the Specification.
- D. All products shall be new and of the latest manufacturer's design. Warranty of all products shall start on the date of final acceptance of the work.
- E. All products shall be provided complete with all mounting hardware, brackets, and miscellaneous accessories whether stated in the individual product specification or not. Specific product options that are required to meet all design requirements indicated on the Drawings, stated in the sequence of operation, shown on the electrical ladder diagrams, and elsewhere in the contract documents shall be specified when the product is ordered and indicated on the catalog data sheet provided with the submittal.

2.8 DUCT STATIC PRESSURE STATION

- A. Provide at each duct static pressure measuring location a traverse probe capable of continuous monitoring of static pressure. The probe shall contain multiple static pressure pickup points along the exterior surface of the cylindrical probe, internally connected to their respective averaging manifold. Each probe shall be extruded aluminum construction with threaded end support rod and nut, and mounting plate with gasket. Each probe shall be sized to span the entire duct and not extend past either side. The probe shall not produce a measurable pressure drop and shall produce a non-pulsating signal with an accuracy of 0.5 percent of total span. Air Monitor Model STAT-Probe/1 or equivalent.

2.9 OUTSIDE AIR STATIC PRESSURE PROBE

- A. Outside air static pressure probe shall be constructed of 10 gage, anodized aluminum with a 2" diameter FPT connection. The probe shall be capable of sensing the outside atmospheric air pressure to within 2 percent of the actual value when subject to radial wind velocities up to 80 miles per hour with approach angles up to 30 degrees to the horizontal. Specification based on air monitor S.O.A.P.

2.10 ELECTRONIC DIFFERENTIAL PRESSURE TRANSMITTER

- A. Electronic differential pressure transmitter shall be designed to measure the differential air pressure as indicated on the Drawings or as required. Pneumatic connections shall be 1/4" barbed and the enclosure shall be provided with holes for panel or field mounting. The output shall be a two wire 4-20 mA loop powered device with an input range as indicated in the Drawings but not more than twice the actual measure variable. The accuracy including linearity, hysteresis and repeatability shall be less than ± 1 percent. Setra model C264 or equivalent.

2.11 ELECTRONIC TEMPERATURE ELEMENT AND TRANSMITTER

- A. Zone Space Sensors
 1. Each TUC or ASC controlling a single zone application shall be provided with a space temperature sensor. The space sensor shall include a thermistor packaged or RTD in the

standard UC/sensor design, digital temperature display, and a maintenance communication port.

B. All Other Temperature Sensors

1. Thermistor temperature sensors connected to a TUC or an ASC shall be a Type II thermistor compatible with the attached FMS controller without the need for any signal conversion hardware. The accuracy of the thermistor shall be ± 0.5 deg F over the range of the sensor. Precon ST series or equivalent.
2. RTD temperature sensors shall be 1000 ohm platinum having an accuracy of ± 1 deg F over the entire range. The associated unit mounting transmitter shall generate a linear 4-20 mADC loop powered signal with a maximum input impedance of 675 ohms at 24 VDC.
3. Sensors used for mixed air application shall be 25' averaging type. The sensor span shall have a field set range of range of 32.0 deg F to 160.0 deg F.
4. All chilled water sensors and sensors placed in locations susceptible to condensation (outside or in chilled and condenser water liquid lines with the potential to drop below the ambient dew point) shall be furnished complete with a NEMA 3R enclosure for the electronics. The sensors shall have an immersion length of one half the pipe's diameter plus the length of the pipe tap. The sensors shall have a range of 10.0 deg F to +230.0 deg F. Units shall be furnished complete with a brass thermowell.
5. Duct temperature sensors for supply air temperatures and return temperature shall be a minimum of 18" in length. The sensor span shall have a range of -30.0 deg F to +160.0 deg F.
6. Sensors used for outdoor air temperature shall be provided complete with a sunshield. The sensor span shall have a range of -30.0 deg F to +140.0 deg F.
7. All immersion water, except chilled water sensors, shall have an immersion length of one half the pipe's diameter plus the length of the pipe tap. The sensors shall have a range of +10.0 deg F to +230.0 deg F. Units shall be furnished complete with a brass thermowell.
8. All temperature elements provided for space temperature measurement shall be installed in a white plastic housing.

2.12 AIR FLOW STATION AND TRANSMITTER

A. Pitot Tube Air Flow Element and Transmitter

1. Each airflow traverse probe shall contain multiple total and static pressure sensors located along the exterior surfaces of the cylindrical probe and internally connected to their respective averaging manifolds. The flow sensors shall not protrude beyond the surface of the probes, and shall be the offset type for static pressure and the chamfered impact type for total pressure measurement. The airflow sensing probe's measurement accuracy shall not be affected by directional flow having pitch and/or yaw angles up to 30 degrees. Each airflow traverse probe shall be of extruded aluminum construction and furnished with mounting plates(s), gasket, and signal fittings suitable for HVAC duct installation.
2. Total and static pressure sensors shall be located at the centers of equal areas (for rectangular ducts) or at equal concentric area centers (for circular ducts) along the probe length.

3. Probes shall be AMCA certified and be capable of measuring the airflow rates within an accuracy of ± 2 percent without the use of correction factors. The maximum allowable unrecovered pressure drop caused by the probes shall not exceed 0.025 inches WC at 2000 fpm or 0.085 inches WC at 4000 fpm. The number of probes required for each installation shall be in accordance with the manufacturer's design recommendations. The airflow traverse probes shall be Air Monitor Corporation Model VOLU-probe or equivalent.
4. Pitot tube type air flow element flow stations shall not be used if the manufacturer's recommended upstream and downstream clearances cannot be achieved in the installation. The Contractor shall use thermal anemometer air flow stations in these instances.
5. The transmitter shall be capable of receiving flow signals from the airflow traverse probe and producing an output linear and scaled for air volume. The transmitter shall contain an integral multi-line digital display for use during the configuration and calibration process, and to display one transmitter output during normal operating mode. All transmitter configuration, parameter setting, zero and span calibration, plus display formatting and scaling will be performed digitally in the on-board microprocessor via input pushbuttons. The transmitter will be available in multiple natural spans covering the range of 0.05 inches WC to 25.0 inches WC with an accuracy of 0.25 percent of natural span. The transmitter shall be furnished with a transducer automatic zeroing circuit and be capable of maintaining linear output signals on applications requiring 5 to 1 velocity turndown. Transmitter shall have a NEMA 12 enclosure. This Specification applies to all airflow transmitters. Transmitter shall be Air Monitor VELTRON DPT 2500-plus or equivalent.

B. Thermal Anemometer Air Flow Station

1. The thermal anemometer air flow stations shall use instrument grade self heated Thermistor sensors with thermal temperature sensors. Flow measurement drift shall not exceed manufacturer's repeatability statement for the life of the equipment. The manufacturer shall provide test data for accuracy performance prior to bid date. Vortex shedding arrays are not acceptable. Auto zeroing sensors are not acceptable.
2. The flow station shall be duct mounted with glass encapsulated self-heated Thermistor and epoxy encapsulated temperature sensor. The sensor housing shall be constructed of Noryl with one to four probes (in accordance with the manufacturer's design guidelines). The support struts and support bracket shall be constructed of tubular aluminum.
3. The flow transmitter shall be totally solid state microprocessor based. The unit shall provide a separate analog signal averager for true averaging duct velocity output on ducts requiring multiple probes. The unit shall be 24 VAC powered, isolated from other devices and not grounded. Multiple series probes and averagers wired from a single transformer must be wired in phase. The flow transmitter shall have an aluminum enclosure.
4. The system shall operate over a temperature range of 30 to 160 degrees Fahrenheit. The system shall operate over a velocity range of 0 to 5000 FPM with a pressure drop of less than 0.005 inches WC at 2000 FPM. The unit shall have an accuracy of ± 10 ft./min for flow rates less than 500 FPM and a ± 2 percent of reading accuracy for flow rates greater than 500 FPM. The unit shall have a repeatability of ± 0.2 percent of scale and resolution of 0.4 percent of scale. All electronics shall be housed in a NEMA 12 enclosure if the

unit is mounted outside in the environment.

5. The unit shall have a field selectable output of airflow rate. Ebtron Eliminator Gold series, or equivalent.

2.13 CURRENT TRANSDUCERS

- A. Current sensing transducers shall measure AC current of loads and shall output a 4-20 mADC signal over the measured range of 0 to 60 amps AC. Sensor shall have a minimum of 2.0 percent of full scale accuracy. Unit shall be split core design. Veris Industries Model H-921 or equivalent.

2.14 CURRENT SENSING SWITCH

- A. Current sensing relays shall indicate the status of AC current of motor loads. The transistor switches shall be rated for switching controller DC current up to 0.1 amp continuously at 30 VDC. The setpoint of the contact operation shall be field adjustable from 1 to 135 amps AC. The switch shall be self powering with a switched load LED for local indication. Veris Industries Model H908 or equivalent.

2.15 AIR DIFFERENTIAL PRESSURE SWITCHES

A. Filter/Fan Status Switch

1. Air differential pressure switches shall have an adjustable setpoint of from 0.05" W.C. to 12.0" W.C. One snap acting SPDT Type C switch shall be enclosed under a NEMA 1 enclosure with a 1/2" conduit opening. Contacts shall be rated for 10 amps at 120 VAC. Cleveland AFS series or equivalent.

B. Static Pressure Safety Switch

1. Air pressure switch shall be manually reset type, designed to sense static pressure and break an electrical circuit when the setpoint is exceeded. The setpoint shall be adjustable from 0.4" to 12" W.C. Unit shall be furnished and installed with a static pressure tip. Kele & Associates Model AFS-460 or equivalent.

2.16 ELECTRIC LINE VOLTAGE THERMOSTAT

- A. The thermostat shall be of the bimetallic design with a SPDT set of contacts rated for 120 VAC at 25 amps. Thermostat shall have an adjustable set point of from 50 deg F to 86 deg F with a fixed differential of 2.0 deg F. The cover shall be metal. Barber-Coleman Model No. TC-195 or equivalent.

2.17 ELECTRIC FLOW SWITCH

- A. The switch shall utilize a multi-segment paddle for use in pipes ranging in size from 1" to 8" with a maximum operating pressure of 150 psig and utilize a sealed bronze bellows packless construction. A snap acting SPDT switch rated for 16.0 amps at 120 VAC shall be installed in a NEMA 1 enclosure with 1/2" conduit knockout is used for indoor applications. Johnson F61 series or equivalent.

2.18 ELECTRIC LOW LIMIT (FREEZESTAT)

- A. Freezestat shall have a 20' temperature-sensitive element designed to respond to the lowest temperature to which any 1' length of the element is exposed. The unit shall have an adjustable set point from 35 deg F to 45 deg F. The electrical rating of the two SPDT contacts shall be 10.2 full load amps at 120. Unit shall be complete with an external manual reset lever. Johnson A70 series or equivalent.

2.19 LIQUID DIFFERENTIAL PRESSURE SWITCH

- A. Switch shall have an adjustable setpoint of from 0 to 150 psig and a minimum differential of 1 psig. One snap acting SPDT switch enclosed under a NEMA 4 enclosure with 1/2" conduit opening and rated for 5 amps at 120 VAC shall be provided. Kele & Associates Model 24-013 or equivalent.

2.20 CONTROL RELAYS

- A. Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting silver cadmium Form C contacts, enclosed in dust-proof enclosure. Relays shall be equipped with the necessary mounting base, DIN rail, labels, termination clips, etc., and a coil transient suppression devices. All relays for control by the FMS shall have 24 VAC coils. All other required relays shall have coil voltages appropriate for the installation. IDEC RH series or equivalent.

2.21 CONTROL TRANSFORMERS

- A. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be fused on both primary and secondary taps. Fusing shall not exceed 80 percent of the rated transformer output. Control transformers 100 VA and less may have internal secondary overload if desired but anything over 100 VA must be external fused. Control transformers over 100 VA supplying power to a control panel shall be located external to the control panel.

2.22 AUTOMATIC DAMPERS

- A. All automatic dampers, except for mixing box dampers furnished with air handling units as specified on the Equipment Schedule, shall be furnished under this Section of the Specifications. These dampers shall be installed and mounted under Section 23 3000.
- B. Dampers shall be constructed of extruded aluminum with oilite bronze or Teflon bearings and trunnions of non-corrosive materials. Each blade shall have a positive closing butyl-rubber or neoprene edge seal, and spring-loaded side seals unless otherwise noted. Dampers shall have louvers designed so that the blades are interconnected to give parallel movement. Jack shafting shall be provided for all dampers greater than 24" by 24". Ruskin CD-50 or equivalent.
- C. Parallel Blade Dampers: Provide parallel blade type automatic dampers for return air dampers, two-position dampers, the face section of face and bypass dampers, and where indicated on the Drawings.

- D. Opposed Blade Dampers: Provide opposed blade type dampers for volume control, exhaust and outside air dampers of a mixing section, throttling application and where indicated on Drawings.

2.23 DAMPER ACTUATORS

A. Electronic Damper Actuators

1. The actuator shall be of the direct-coupled design. The fastening clamp assembly shall be of a V-bolt design with associated V-shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a V-clamp assembly of sufficient size to be directly mounted to an integral jack shaft of up to 1.05 inches when the damper is constructed in this manner. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a two (2) year manufacturer's warranty, starting from the date of installation.
2. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
3. Spring return actuators shall be provided for all outside and exhaust/relief air dampers in addition to all locations indicated on the Drawings. Spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
4. Proportional actuators shall accept a 0 - 10 VDC or 0 - 20 mA control input and provide a 2 - 10 VDC or 4 to 20 mA operating range. All actuators shall provide a 2 - 10 VDC position feedback signal and shall have an external, built-in switch to allow the reversing of direction of rotation.
5. All actuators shall not require more than 10 VA regardless of the operating voltage.
6. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in/lb torque capacity shall have a manual crank.
7. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
8. Actuators shall be Underwriters' Laboratories Standard 873 listed and Canadian Standards Association Class 481302 certified as meeting correct safety requirements and recognized industry standards.
9. Manufacturer shall be ISO9001 certified. Actuators shall be manufactured by BELIMO or equivalent.

2.24 CONTROL VALVES

A. Ball Control Valves Three Inches and Less.

1. Two-way control valves shall be industrial quality with bronze bodies and female NPT threads. Valve bodies may also be stainless steel, titanium or nickel with operating

- pressure up to 2000 psi. The maximum operating differential shall be **[5]** psi for water.
2. All valves shall have blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating. Stem packing gland screw shall be adjustable for wear.
 3. Standard chromium plated stainless steel ball and stem, shall be rated at a minimum of 600 psi WOG (water-oil-gas), cold, non-shock, and 150 psi for saturated steam service. All valves shall be provided with reinforced Teflon seats.
 4. Belimo, Bray, or equivalent.
- B. Two- and Three-Way Globe Control Valves Two Inches and Less.
1. Valves 1/2" through 2" shall be bronze, screw type, and shall be rated at 250 psi maximum working pressure for water and steam.
 2. Valve stems shall be stainless steel, highly polished, corrosion-resistant, alloy to decrease friction and increase response. Valve plugs shall be brass and guided to ensure perfect seating.
 3. Stem packing shall be spring loaded EP V-rings for water applications and Teflon V-rings for steam applications to eliminate leakage around the stem and ensure a minimum amount of stem friction. Stem lift shall be 1/2" to 3/4".
 4. Flow type shall be equal percentage for water. The maximum operating differential shall be 5 psi for water.
 5. Composition discs shall be replaceable and provide tight shutoff.
 6. Belimo, Bray, or equivalent.
- C. Two- and Three-Way Globe Control Valves Greater than Two Inches.
1. Valves 2-1/2" through 6" shall be cast iron flanged, and rated at 125 psi maximum working pressure. The maximum working temperature shall be 300 deg F/149 deg C.
 2. Valve plug stems shall be stainless steel, highly polished, corrosion-resistant, alloy to decrease friction and increase response. Valve plugs shall be brass and guided to ensure perfect seating. Stem packing shall be Teflon, spring loaded EP V-rings to eliminate water leakage around the stem and ensure a minimum amount of stem friction. Lift shall be 3/4" to 1-1/2".
 3. Flow type shall be equal percentage. The maximum recommended differential shall be **[5]** psi. Composition discs shall be replaceable and provide tight shutoff.
 4. Belimo, Bray, or equivalent.
- D. Control Butterfly Valves
1. Valve body shall be of the full lug-wafer style, drilled and tapped for isolation and removal of downstream piping. Flanges shall meet ANSI 125 and 150 standards. The body shall feature an extended neck allowing for sufficient clearance for flanges and piping insulation. The cast-in top plate shall allow for direct mounting of all actuators.
 2. The disc and hub edge shall be rounded and hand polished to a 32 AARH or better finish to protect seats from damage and to reduce frictional torque. The disc shall have a full 360 degree concentric seating, minimum flow restriction and self-locking stainless steel disc to stem screws for quick and easy disassembly. A torque plug shall provide a positive leak-proof connection of the disc to the stem.

3. Valves shall feature a single, through-shaft design for high strength and positive disc control.
4. The seat shall be heavy duty with molded-in O-rings creating a positive seal between flange face and valve body. No gaskets shall be required between the valve and flange faces. The resilient seat shall provide a bubble-tight shutoff in either direction with the disc closed. Seat design shall isolate the body and stem from the flowing media. The seat shall not be bonded to the valve body and shall be easily replaceable in the field.
5. The primary steam seals shall be formed by preloaded contact of the disc hub with flatted seat surfaces. The secondary stem seal shall be formed by an engineered interference fit (stem diameter larger than stem passage hole) of the stem through the seat. An internal bi-directional stem seal, located in the upper journal, shall be self-adjusting and support full vacuum and pressure to prevent contamination of the stem area and act as a tertiary seal to line pressure.
6. The top bushing, located in the upper journal, shall be non-corrosive and heavy duty to absorb actuator side thrust. Upper and lower non-wetted, metal inboard stem bearings shall be isolated from the flow media.
7. All valves are factory tested to 10 percent of specified pressure rating. The lugged version is rated for 50 psi dead-end service for removal of downstream piping.
8. Belimo, Bray, or equivalent.

2.25 CONTROL VALVE ACTUATORS

A. Electronic Valve Actuators

1. Ball valves actuator shall be fully modulating using 2-10 VDC or 4-20 mADC, floating point, two-position spring return as indicated in the control sequence. Fail safe, where specified, shall require mechanical spring return. The actuator shall be positive positioning, responding to a 2-10 VDC or 4-20 mA signal (with the addition of a 500 ohm resistor). There shall be a visual valve position indicator. Power shall be 24 VAC unless indicated otherwise on the Drawings and shall not exceed 8 watts at 24 VAC. A 3-foot cable shall be provided for easy installation to an electrical junction box. The actuator shall provide minimum torque required for proper valve close-off, with an approximate running time of two (2) minutes for full rotation. The actuator shall be designed with current limiting motor protection. (End of travel switches and magnetic clutches are not acceptable.) A release button on the actuator shall be provided to allow for manual override, except when utilizing spring return actuators.
2. Ball Valves: All actuators shall be UL listed. The manufacturer shall warranty all the actuators and valve assemblies for a period of two (2) years from date of installation.
3. The actuators and valves shall be factory mounted and tested and supplied. Belimo, Bray, or equivalent.

2.26 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

- A. Provide interlock wiring between supply and exhaust fans, electrical wiring for relays (including power feed) for temperature and pressure indication. Provide interlock wiring between refrigeration machines, pumps and condensing equipment as required for the specified sequence of operation and the refrigeration system integral controller(s). Do not provide interlock wiring if a dedicated digital output has been specified for the equipment or the

sequence of operation requires independent start/stop.

- B. Provide power wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices for temperature, humidity, pressure and flow indication, point resets and user disconnect switches for electric heating, appliances controlled by the FMS.
- C. Provide all other wiring required for the complete operation of the specified systems including control power wiring not expressly stated to be provided by Division 26.
- D. Install all wiring raceway systems complying with the requirements of the National Electrical Code and Division 26. All installations shall be installed in EMT.
- E. FMS Network Communication Requirements
 - 1. Wired network communication shall be via channels consisting of communications wire installed in a 3/4" EMT] [of plenum cable installed in the ceiling.
 - 2. Telephone lines, where required as a remote communication source, shall utilize voice band, non-switched, private line channels consistent with Bell Systems Technical Reference Publication 41001 and shall be four-wire unconditioned 3002 channels. The modems shall have 25 pin EIA connectors and RS-232C interface.
 - 3. Communication conduits and wiring shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.
 - 4. All shields shall be ground (earth ground) at one point only, to eliminate ground loops.
 - 5. There shall be no power wiring, in excess of 30 VAC rms, run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, all communication wiring and signal wiring shall be run using separate twisted shielded pairs (24 AWG) with the shields grounded in accordance with the manufacturer's wiring practices.
- F. Power and Communication Wiring Transient Protection
 - 1. The control manufacturers shall submit catalog data sheets providing evidence that all FMS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
 - 2. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General Semiconductor, Model #422E device.
 - 3. The communications circuitry, input/output circuitry, and CUs, shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the FMS controller. Protection shall be

provided for the individual communications and input/output terminations for each FMS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

G. Input/Output Control Wiring

1. RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22 gage.
2. Other analog inputs shall be a minimum of number 22 gage, twisted, shielded.
3. Binary control function wiring shall be a minimum of number 18 gage.
4. Analog output control functions shall be a minimum of number 22 gage, twisted, shielded.
5. Binary input wiring shall be a minimum of number 22 gage.
6. Thermistors shall be equipped with the manufacturer's calibrated lead wiring.
7. 120V control wiring shall be #14 THHN in 3/4" conduit. Provide 4 or 20 percent fill extra wire in each conduit.

H. Splices

1. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein.

I. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

2.27 TEMPERATURE CONTROL PANELS

- A. Control panels shall be provided as required for mounting of system control devices as indicated on the Drawings. Panel shall be sized as required to accommodate controls with hinged door, key lock. Panel shall be constructed of metal with metal mounting backplanes. All panels shall be supplied with the same key. All panels shall be NEMA rated and UL listed. Hoffman or equivalent.

2.28 INDOOR AIR QUALITY SENSOR

- A. The indoor air quality (IAQ) sensor shall be specifically designed to generate a linear 0-10 VDC signal proportional to a 0.0-100% air quality unit where 0.0% is very poor, 100 percent is very good, and 50% is average. The components making up the air quality measurement shall

include CO₂ and Volatile Organic Compounds (VOC). The sensor shall mount directly on a duct and shall be powered from a 24 VAC power source. Siemens QPA63.2 or equivalent.

2.29 EQUIPMENT CONNECTIONS

- A. Not Applicable.

2.30 ELECTRONIC LIQUID DIFFERENTIAL PRESSURE SENSOR

- A. Electronic differential pressure transmitter shall be designed to measure the differential liquid pressure as indicated on the Drawings or as required. Liquid connection shall be 1/4" NPT and the enclosure shall be NEMA 4 with 1/2" conduit knockouts. The output shall be a two wire 4-20 mA loop powered device with an input range as indicated in the Drawings but not more than twice the actual measure variable. The accuracy including linearity, hysteresis and repeatability shall be less than or equal to $\pm 0.25\%$ of full scale. Setra Model C230 or equivalent.

2.31 ELECTRONIC LIQUID PRESSURE SENSOR

- A. Electronic pressure transmitter shall be designed to measure the liquid gauge pressure as indicated on the Drawings or as required. Liquid connection shall be 1/8" NPT. The unit shall have an accuracy of $\pm 0.13\%$ of full scale. The unit shall have stainless steel media. Setra Model C206 or equivalent.

2.32 INDOOR STATIC AIR PROBE

- A. Indoor static air probes shall be provided for each indoor air pressure measurement location. They shall be flush mounted with a concealed connection. They shall be constructed of 10 gage aluminum with a 1/8" coupling for output signal connection. Air Monitor S.A.P. or equivalent.

PART 3 - EXECUTION

3.1 GENERAL

- A. All devices, conduit, wiring, etc., shall be installed in a neat professional manner by skilled persons.
 - 1. The installation of all aspects of the system shall comply with all applicable codes and regulations and with Division 26 Specifications.
 - 2. The installation of all materials shall be in accordance with the published manufacturer's recommendations without exception. If for some reason a particular component cannot be installed in compliance with these recommendations, the Contractor shall advise the Engineer of the situation.
 - 3. Where miscellaneous materials are required to complete an installation, i.e., isolation valves for pressure switches, wall switches for an exhaust fan control circuit, etc.; the materials shall be supplied as defined in the relevant Section of these Specifications. For example, Section 23 0523 specifies valve requirements, and Division 26 specifies electrical products and requirements.
 - 4. Coordinate with other trades where installation of a particular component requires other

trades to be involved. Installation coordination includes location the correct placement of thermowells, flow switches, dampers, control valves, control power circuits, etc. Care must be exercised to identify locations that meet the requirements of the manufacturer including upstream and downstream distances, pressures, temperatures, etc.

3.2 PRIMARY OPERATORS STATIONS

- A. The existing primary operator workstation[s] shall be used for this project. All of the software development specified in this paragraph shall be implemented/upgraded on the workstation.
- B. User Access
 - 1. The Owner shall be interviewed and all desired passwords and password levels shall be installed at all workstations.
- C. Reports
 - 1. The Owner shall be interviewed and all reports desired shall be completely configured including correct formatting, delivery frequency, etc.
- D. Dynamic Color Graphic Displays
 - 1. All color graphic slides shall be developed to the satisfaction of the Owner. The slides shall include all realtime point assignments, user interactive points, and realtime alarm information. At a minimum, the following graphic slides shall be developed:
 - a. A graphic shall be provided for each temperature zone of each floor. This graphic shall be a "Zoom" view of the selected temperature zone of the respective floor plan. All information displayed on the building floor plan relative to any particular temperature zone and all color coding of the temperature zone shall be the same as was provided for the floor plan graphics. "Pick" windows shall be provide on these graphics to permit the operator to view specific mechanical system graphics relative to the respective floor plan.
 - b. Separate graphics shall be provided for all mechanical equipment serving the respective building or zone. This includes all central station units, boiler plant, air compressors, central plant, etc. Mechanical system graphics shall be displayed complete with all real time data relevant to the equipment being displayed including temperatures, flow rates, positions, etc.
 - 2. Database Save/Restore/Backup
 - a. After all FMS controller software, operator workstation software, and graphic slides have been developed, two (2) complete backup sets of this software shall be delivered to the Architect for archiving.

3.3 FMS CONTROLLERS

A. General

1. All FMS controllers shall be installed in accordance with manufacturer's instructions. Power shall be provided to each FMS controller in accordance with Division 26 and all applicable codes.
2. All FMS controllers shall be installed in an enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Input/Output

1. All points listed in the Point Summary (Appendix A) or required to meet the Sequence of Operation (Appendix B) shall be connected to the respective FMS controller in accordance with the manufacturers instructions. Each point shall be checked for voltage, short circuit, etc., prior to termination to the FMS controller to prevent potential damage to the controller.

C. Software Requirements

1. General

- a. All sequences of operation listed on the Drawings are to be implemented as they relate to the points shown on the Drawings. Any additional points required to meet the sequence of operation shall be provided whether indicated on the Drawings or not. In addition to the sequences of operation indicated on the Drawings, the following general sequences shall be implemented.

2. Optimal Start

- a. Develop software to start all equipment based on the individual zone temperature, outside air temperature, heating/cooling capacity in degree Fahrenheit/hour of the equipment serving that zone and the previous optimal start time in establishing the optimal start time for the following day. The optimal start program shall work in conjunction with the scheduled start time to minimize energy consumption.
- b. In no case shall the optimal start routine keep the AHU from running after the occupancy start time identified as the scheduled start time.
- c. The AHUs shall run continuously until the scheduled stop time. No optimal stop program time shall be provided.

3. Run Time Totalization

- a. All digital input and output points shall be setup to accumulate run time information. Maximum run time limits shall be defined and shall automatically issue a printed message as defined by the Owner.

4. Alarms
 - a. All analog input points shall have upper and lower limits established and alarms shall be generated in the event these limits are exceeded. The Contractor shall define reasonable limits for these alarm points. Digital inputs shall be compared to the associated digital outputs (fan start/stop and status) and alarms shall be issued if the commanded position is inconsistent with the actual condition, after a start delay timer. All alarms shall be directed to the primary operator workstations and shall be archived on the hard drives.
5. Minimum Runtimes
 - a. All digital output points shall have a minimum runtime of five (5) minutes to prevent accidental short cycling.
6. Staggered Starts
 - a. All digital outputs shall have staggered start times of at least 30 seconds to minimize demand spikes.
7. Trend Analysis (DDC Controller and all attached TCUs and ASCs)
 - a. In order to verify and document satisfactory system operation, at a minimum, all trend logs defined in Appendix A shall be developed and implemented. As work of this Section, all control loops, inter-start delays, minimum and maximum run times, etc., shall be tuned to meet the constraints listed in Appendix A.
 - b. All analog and digital trend logs shall be printed in text form with a graph of the corresponding trend data attached as the cover to the text trend data.
 - c. All trend graphs shall be printed, maximized in landscape form, on one 8.5" x 11" sheet of paper. Graphs requiring the display of more points than can be reasonable displayed on one graph may be graphed on separate sheet, however, the time stamps of each graph must match exactly so that data from multiple graphs may be compared.
 - d. Each analog graph shall include an "x" time/date axis scale and one or two "y" axis scales as required to adequately display the trend data. Each digital trend may be of any style and developed such that overlapping digital sequences are obvious to the viewer. Each axis shall be labeled and scaled. Axis scaling shall be set to clearly show the desired control response and required trend duration. A legend shall be provided clearly defining each trend line. Graphs may be color or black and white, however, black and white graphs must use patterns making the information clearly understandable. The time and date of displayed data shall be provided on both the text trend log printout and the graph printout. Examples of the minimum level of detail that will be required for all trend graphs are included in Appendix B of this Section.
 - e. If trend logs are printed and graphed using cryptic systems point names, a legend shall be provided with each trend to make the translation of the trended points easily understood.

- f. All required trends, graphs, and completed point verification forms shall be compiled into a project closeout notebook(s) with tabs indicating the system being trended. For example, point verification forms for AHU-1, the supply air temperature control loop for AHU-1, the static pressure control loop for AHU-1, and the mixed air temperature control loop for AHU-1 shall be included under a tab labeled AHU-1. Zone trend data may be grouped under logical headings by AHU, floor, etc. A complete detailed index of all trend data and graphs shall be included in the front of the notebook(s). A page shall also be included in the front of the notebook identifying who performed which trend log.
- g. The completed closeout notebook(s) shall be provided as part of the close out documentation required in Section 23 0500. Acceptance of the system will not be given until this requirement is met.

3.4 APPLICATION SPECIFIC CONTROLLERS

A. General

- 1. A maximum of one ASC shall be installed on each piece of equipment (i.e., blower coil unit, air handling unit, makeup unit, etc.) and a maximum of one piece of equipment shall be connected to one ASC.
- 2. Power shall be provided to each ASC and installed in accordance with Division 26 and all applicable codes.
- 3. All FMS controllers shall be installed in an enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Input/Output

- 1. All points listed on the Drawings or required to meet the sequence of operations shall be connected to the respective ASC in accordance with the manufacturer's instructions. Each point shall be checked for voltage, short circuit, etc., prior to termination to the FMS controller to prevent potential damage to the controller.

3.5 TERMINAL UNIT CONTROLLER

A. General

- 1. A maximum of one (1) TUC shall be installed on each piece of equipment (i.e., fan coil, VAV box, etc.) and a maximum of one piece of equipment shall be connected to one (1) TUC.
- 2. Power shall be provided to each TUC and installed in accordance with Division 26 and all applicable codes.
- 3. All FMS controllers shall be installed in an enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Input/Output

1. All points listed on the Drawings or required to meet the sequence of operations shall be connected to the respective TUC in accordance with the manufacturer's instructions. Each point shall be checked for voltage, short circuit, etc., prior to termination to the FMS controller to prevent potential damage to the controller.

3.6 OPERATOR INTERFACE PANELS

- A. The operator interface panel shall be installed on or near the FMS control panel or as indicated on the Drawings. The panel shall be connected to the FMS network and programmed to allow the functionality described in Section 2.6 of this Specification.
- B. The Owner shall be interviewed and all desired passwords and password levels shall be installed at the interface panel.

3.7 NETWORKING/COMMUNICATIONS

A. General

1. All LANs shall be installed in a manner recommended by the manufacturer, owner's representatives, based on the environment, communications speed requirements, and distance. All LAN media shall be installed in a manner that provides protection from physical damage and interference from RF or other electrical sources.

B. Primary Local Area Network (LAN)

1. The primary LAN is existing; however, all media required to connect new operator workstations or FMS controllers/routers to the primary LAN shall be installed with materials and procedures that comply with the requirements of the facility communications personnel and the FMS equipment manufacturer. All new FMS controllers/routers shall be connected to the LAN.

C. FMS Controller Local Area Network (LAN)

1. The controller LAN shall be installed with materials and procedures that comply with the requirements of the FMS equipment manufacturer. In general, the conductors are to be a 22 gage, low capacitance, and twisted pair. All FMS controllers (if not connected to the primary LAN) and ACS controllers shall be connected to the LAN.

D. Sub-Controller Local Area Network (LAN)

1. The sub-controller LAN shall be installed with materials and procedures that comply with the requirements of the FMS equipment manufacturer. In general, the conductors are to be a 22 gage, low capacitance, twisted pair. All TU controllers shall be connected to the LAN.

3.8 DUCT STATIC PRESSURE STATION

- A. Ensure that the direction of flow is observed when installing the probe to prevent measurement of total pressure. The connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Connections from the "HI" pressure port to the differential pressure transducer shall be 1/4" plastic tubing which shall not extend for more than ten feet. Pressure stations shall be installed 2/3 the distance down the duct of all major branch ducts or as indicated on the Drawings.

3.9 OUTSIDE AIR STATIC PRESSURE PROBE

- A. Outside air static pressure probe must be installed and piped according to manufacturer's instructions to ensure accuracy of the static pressure reading and eliminate the effects of condensation in the sensing lines. Coordinate installation of probe with the necessary trades for proper sealing of all roof penetrations.

3.10 ELECTRONIC DIFFERENTIAL PRESSURE TRANSMITTER

- A. All differential pressure transmitters shall be installed within ten feet of the pressure sensing point. The transmitters shall be installed in a NEMA I housing for interior conditioned spaces and in NEMA 3R housings for outside or unconditioned spaces. The transmitters and housings shall be rigidly supported to prevent vibration and shall never be mounted to ductwork or piping. Access to the transmitter shall be provided.

3.11 ELECTRONIC TEMPERATURE ELEMENT AND TRANSMITTER

- A. Space temperature transmitters shall be installed 60" A.F.F. If a setpoint adjustment is provided on the sensor then the unit shall be installed 48" A.F.F. unless otherwise specified on the plans.
- B. All temperature sensors installed in liquid lines, tanks, etc., shall be installed in stainless steel thermowells. The thermowells shall be supplied to the mechanical contractor for installation under other Sections of the Specification. A thermo-conductive paste shall be applied between the sensing element and the thermowell.
- C. Outdoor air temperature elements shall be installed in a location that is continuously shaded and not effected by heat generating equipment or equipment intakes or discharges. The element shall be installed under a sun shield and high enough to avoid damage from vandalism.
- D. Duct point temperature elements shall be installed directly on ductwork and the connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Care must be taken to avoid direct contact between the temperature element and any heat transfer surface such as a coil.
- E. Duct averaging elements shall be installed with the same requirements as for the temperature point elements; however; the averaging elements shall be extended across the entire duct area in a zigzag pattern. Special clips shall be used to secure the elements at turns to prevent chafing of the elements. Where the elements pass through the duct, plastic tubing or similar protection shall be installed on the elements to prevent damage to the elements from vibration.

3.12 AIR FLOW STATION AND TRANSMITTER

A. Pitot Tube Air Flow Element and Transmitter

1. Ensure that the direction of flow is observed when installing the station in the ductwork. The station shall be installed in accordance with manufacturer's published up- and down-stream duct length requirements.
2. All connection points shall be secured. Connections from the "HI" and "LO" pressure ports to the air flow transmitter shall be 1/4-inch plastic tubing which shall not extend for more than ten feet.
3. The flow transmitter shall be wall mounted with the display at 60" A.F.F. The flow transmitter shall be completely setup to meet the actual field measurement conditions and output CFM. Provide 24 VAC power for transmitter.

B. Thermal Anemometer Air Flow Station

1. Ensure that the direction of flow is observed when installing the station in the ductwork. The station shall be installed in accordance with the manufacturer's published up- and down-stream duct length requirements. If a suitable location for the flow station cannot be achieved, the Contractor shall consult with the engineer and manufacturer with possible alternative locations.
2. All connection points shall be secured. Provide all power requirements for the unit and connect to the FMS.

3.13 CURRENT TRANSDUCERS

- A. Current transducers shall be installed on one hot leg of either single or three phase and after the local disconnect. The transducers shall be located in the motor starter housing or motor control center and secured to the structure using sheet metal screws.

3.14 CURRENT SENSING SWITCH

- A. Current switches shall be installed in one leg of three phase circuits and the hot leg of single phase circuits and in all cases, after the local disconnect. The switches shall be adjusted to close at approximately 10% of the attached loads full load amps.

3.15 AIR DIFFERENTIAL PRESSURE SWITCHES

- A. Differential pressure switches shall be connected to pitot tube pickup probes pointing into the air stream on both sides of the process variable. Connection between the switch and the pitot tubes shall be 1/4" hard copper. The switches shall be adjusted to close at approximately 25% of the fans maximum speed or at the dirty filter pressure differential.

3.16 ELECTRIC LINE VOLTAGE THERMOSTAT

- A. Where thermostats are to be mounted remotely from the controlled device, all conductors shall be installed in a metallic raceway and the thermostat shall be mounted on a junction box. Mount the thermostat 48" A.F.F. unless otherwise specified on plans.

3.17 ELECTRIC FLOW SWITCH

- A. Flow switches shall be installed in a Thread-O-Let installed under Sections of the Specification. The paddle of the flow switch shall be selected and the spring adjustment shall be carefully set to provide good switching between flow and no flow conditions. Ensure that the flow direction of the device matches the actual flow direction.

3.18 ELECTRIC LOW LIMIT (FREEZESTAT)

- A. Low limit thermostats shall be installed with the averaging element extended across the entire duct area in a zigzag pattern. Special clips shall be used to secure the element at turns to prevent chafing of the element. Where the element pass through the duct, plastic tubing or similar protection shall be installed on the element to prevent damage to the element from vibration. The thermostat setpoint shall be set as indicated and the circuit shall be tested to ensure actions as required.

3.19 LIQUID DIFFERENTIAL PRESSURE SWITCH

- A. Differential pressure switches shall be connected to pressure taps installed on the piping under other Sections of the Specification. The connections shall be 1/4" hard copper complete with isolation valves on both lines. The switch shall be supported either by mounting on a wall or on a frame constructed from Unistrut. The switch setpoint and differential shall be set as necessary to provide good switching between pressure and no pressure conditions.

3.20 CONTROL RELAYS

- A. Control relays shall be field or panel mounted as indicated on the Drawings. If a relay is field mounted it will be installed in a NEMA I housing.
- B. Control relays shall be installed in bases and the based mounted on a DIN rail. All accessories including end clips, jumpers, etc., shall be provided. All wiring shall be labeled. Multiple conductors shall be bundled and run by classification in plastic wireways. Relays shall be labeled as indicated in the shop drawings for ease in troubleshooting.

3.21 CONTROL TRANSFORMERS

- A. Control transformers shall be field mounted using a plate to mount on the associated junction box or panel using a foot-style mounting. Locations shall be as identified on the Drawings or as determined by field requirements. A phenolic label on each transformer shall identify the power source by breaker panel and circuit. Fusing of the primary and secondary sides and sizing shall be as defined by the NEC. Provide means of local disconnect for transformer to allow removal.

3.22 ELECTRIC-PRESSURE SWITCHES

- A. Switches shall be panel mounted unless otherwise indicated. Pneumatic connections within the panel may be 1/4" plastic tubing. Switches shall be identified with a phenolic label for ease in troubleshooting.

3.23 AUTOMATIC DAMPERS

- A. All automatic control dampers shall be installed under Section 23 3000.

3.24 DAMPER ACTUATORS

- A. Electronic Damper Actuators
 - 1. Damper actuators shall be mounted on the damper jack shaft or shaft extender using a V-clamp. The actuator shall then be anchored to the ductwork housing the damper. All power requirements for the actuators shall be supplied under this Section of the Specification.

3.25 CONTROL VALVES

- A. The valves shall be installed by the mechanical contractor under other Sections of the Specification.

3.26 CONTROL VALVE ACTUATORS

- A. Electronic Valve Actuators
 - 1. Valve actuators shall be supplied factory assembled with the respective control valve.

3.27 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

- A. Comply with all Division 26 installation requirements.
- B. Install low voltage power in conduit in the following locations regardless of local building code allowances otherwise.
 - 1. Mechanical rooms.
 - 2. Electrical rooms.
 - 3. Vertical risers. (Exception: fire rated continuous closet like a telephone closet.)
 - 4. Open areas where the wiring will be exposed to view or tampering.
 - 5. Hard ceilings and walls.
- C. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.
- D. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:
 - 1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
 - 2. All cables shall be UL listed for application; i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.
 - 3. Class 2 wiring shall be run parallel along a surface or perpendicular to it, and NEATLY tied at ten foot intervals.

4. Exposed Class 2 wiring shall not be installed in lengths longer than ten feet.
 5. Exposed Class 2 wiring shall only be used in cases where the wiring is factory mounted to the control device or on terminal units (i.e., wiring between terminal unit valves and damper actuator and the terminal unit controller).
- E. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- F. All wire-to-device connections shall be made at terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- G. Plug or cap all unused conduit openings and stubups. Do not use caulking compound.
- H. Route all conduit to clear beams, plates, footings and structure members. Do not route conduit through column footings or grade beams.
- I. Set conduits as follows:
1. Expanding silicone firestop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.
 2. Oakum and lead, sealed watertight penetration through outside foundation walls.
- J. Cap open ends of conduits until conductors are installed.
- K. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18" and maximum length of 36" shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.
- L. Where exposed to the elements or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.
- M. Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.

3.28 TEMPERATURE CONTROL PANELS

- A. All tubing and wiring shall be clearly labeled with Brady-type marker labels and run to numbered terminal strips or tubing manifolds these wire, tube, and terminal numbers shall be shown on all control diagrams. Wires and tubes shall be labeled at all connection points.
- B. All control devices shall be labeled with engraved phenolic tags showing device number and name, model number, setpoint, range, action, etc. Panel Face indicators shall be labeled with engraved phenolic tags identifying what is shown on indicator.

- C. Hard tubing shall be brought into the panel using bulkhead fittings; tubing within the panel may be plastic.
- D. Electronic digital indicators shall be provided where shown on the Drawings. Indicators shall be LED or LCD loop powered type and fully compatible with the associated transmitter and matched to the range of the transmitters. Indicators shall be flush mounted on the control panel door.
- E. Terminal strips shall be provided in all control panels for the termination of all field wiring. An additional 25% but not more than 50 terminal strips shall be provided for future use. Terminal strips shall be rated for no less than 300 VAC, 1/4" in width, track mounted, and a slot provided for labeling strips. All terminals shall be labeled as shown on the as-built drawing. No more than two conductors shall be terminated on a single terminal.
- F. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be provided with a phenolic label identifying the source of power.
- G. Control panel front mounted pilot lights shall be provided where shown on the Drawings or electrical ladder diagrams. Lights shall have replaceable bulbs and lenses and shall incorporate a "push-to-test" feature. Voltage rating of pilot light may be full load voltage or dropped across a line resistor. In no case may the voltage to pilot lights exceed 120 VAC.
- H. Control panels shall have wire ways installed to group all wiring within a panel. Panels shall be manufactured in a professional manner to the satisfaction on the Owner and Engineer.

3.29 INDOOR AIR QUALITY SENSOR

- A. The indoor air quality (IAQ) sensor shall be mounted on the ductwork where indicated on the Drawings. Exercise caution during installation to prevent contamination of the sensor element.

3.30 EQUIPMENT CONNECTIONS

- A. FMS Class II field wiring for all non-control device applications shall be installed under this Section of the Specification. This includes equipment such as VFDs, chillers, boilers, packaged air handling equipment, etc., that may have point types include status or alarm monitored from an equipment supplier Class C contact or analog control signals to equipment, etc.

3.31 ELECTRONIC LIQUID DIFFERENTIAL PRESSURE TRANSMITTER

- A. All liquid differential pressure transmitters shall be installed within ten feet of the pressure sensing points. The transmitter shall be rigidly supported to prevent vibration and shall never be mounted to ductwork or piping. The piping for the sensing points shall include isolation valves such that the transmitter can be removed without having to shut down the liquid system. Access to the transmitter shall be provided.

3.32 ELECTRONIC LIQUID PRESSURE TRANSMITTER

- A. All liquid pressure transmitters shall be installed within ten feet of the pressure sensing ports. The transmitter shall be rigidly supported to prevent vibration if it is not directly connected to the pipe. The piping for the sensing points shall include isolation valves such that the transmitter can be removed without having to shut down the liquid system. Access to the transmitter shall be provided.

3.33 INDOOR STATIC AIR PROBE

- A. Indoor static air probes shall be mounted in the ceiling in locations indicated on the Drawings or as required.

END OF SECTION 23 0900

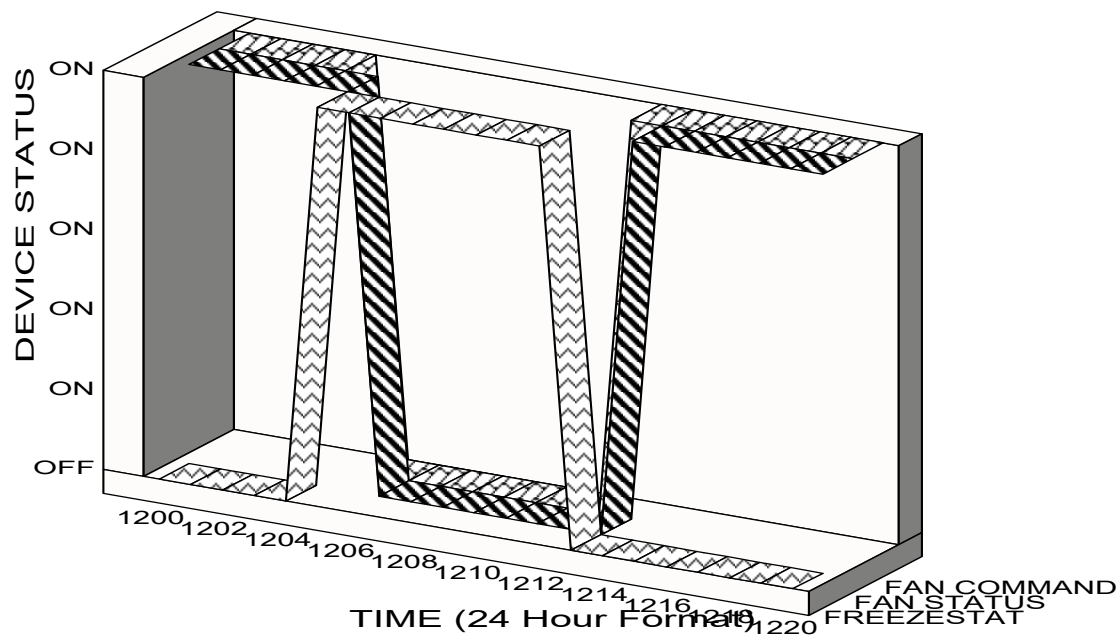
APPENDIX A**Verification Trend Log Development and Acceptance Requirements**

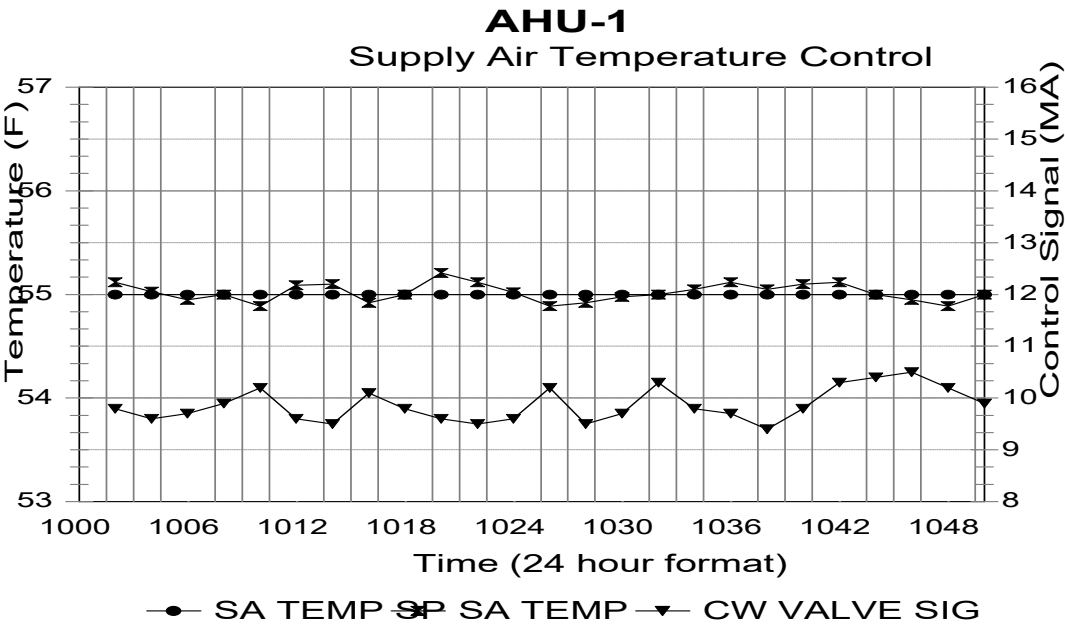
AHU-1 TREND LOG REQUIREMENTS			
Trend #1 (Supply Air Temperature Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes during occupied mode	1 minute	SA temperature SA temperature set point Chilled water valve control signal	SA temperature $\pm 0.5^{\circ}\text{F}$ of SA temperature SP with hunting of no more than 5% of the control signal
Trend #2 (Supply Air Static Pressure Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes during occupied mode	1 minute	SA static pressure SA static pressure set point VFD control signal	SA pressure $\pm 0.05^{\circ}\text{F}$ of SA static pressure SP with hunting of no more than 5% of the control signal
Trend #3 (Mixed Air Temperature Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes during occupied mode	1 minute	MA temperature MA temperature set point Mixing damper control signal	MA temperature $\pm 0.5^{\circ}\text{F}$ of MA temperature SP with hunting of no more than 5% of the control signal
Trend #4 (Fan Safety Test)			
Trend Duration	Sample Interval	Trend Points	Required Test Sequence
N/A - Allow 2 minutes between test sequence events	1 minute	Fan commanded position Fan (VFD) status Freezestat Condition Supply air smoke detector Return air smoke detector MA damper signal	1) Fan stopped, safeties normal; 2) Fan commanded on, safeties normal; 3) Freezestat tripped; 4) Freezestat reset; 5) SA Smoke detector tripped; 6) SA smoke detector reset; 7) RA smoke detector tripped; 8) RA smoke detector reset;

VAV TERMINAL UNIT TREND LOG REQUIREMENTS			
Trend #1 (Space Temperature Control Range Test)			
Trend Duration	Sample Interval	Trend Points	Required Test Sequence
N/A - Allow full system response recovery between test sequences	1 minute	Space temperature Space temperature set point HW valve control signal Primary air control damper signal Primary air flowrate Primary air flowrate set point Primary air flowrate maximum Primary air flowrate minimum	1) Space temperature at or near set point; 2) Adjust space temperature set point 3.0°F below actual temperature; 3) Adjust space temperature set point 3.0°F above actual temperature; 4) Return space temperature set point to design condition;
Trend #2 (Space Temperature Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
24 Hours – including transitions from unoccupied to occupied and occupied to unoccupied modes	10 minute	Space temperature Space temperature set point	Space temperature remains within $\pm 0.5^{\circ}\text{F}$ of space temperature set point with hunting of no more than 5% of the control signal for the hot water or primary air flow rates.

APPENDIX B
Typical Trend Graph Requirements

AHU-1
Fan Safety Sequence Test





APPENDIX C
Typical Point Verification Form

POINT VERIFICATION FOR AHU-1						
Point Description	Software Point Name	Point Type	Date Tested	Results (Pass/Fail)	Contractor Initials ⁽¹⁾	Inspector Initials ⁽²⁾
SA Temp Sensor	AH1SATMP	AI	11/1/99	Pass	RTC	ALM
SA Static Press	AH1SASTAT	AI	11/1/99	Pass	RTC	ALM
Fan S/S	AH1SAFSS	DO	10/14/99	Pass	RTC	ALM
Fan Status	AH1SAFST	DI	10/14/99	Pass	RTC	ALM
Freezestat ⁽³⁾	AH1FZ	DI	10/13/99	Pass	RTC	ALM
CW valve control	AH1CWV	AO	10/14/99	Pass	RTC	ALM

- (1) RTC is Robert T. Conbert of Acme Control Company, Inc.
- (2) ALM is Albert L. Mackey, P.E. of Zebra Commissioning Company, Inc.
- (3) Freezestat is also hard wired to stop fan in the hand or auto position. These interlocks were tested on the same day.

SECTION 23 2313

REFRIGERANT PIPING SYSTEM AND EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Conform to the applicable provisions of the General Conditions, the Supplemental General Conditions and the General Requirements.

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 0504, Pipe and Pipe Fittings.
- C. Section 23 0505, Piping Specialties.
- D. Section 23 0523, Valves.
- E. Section 23 0700, HVAC Insulation.
- F. Section 23 0900, Facility Management System, for temperature control valves, meters and instrumentation.
- G. Division 26, Electrical.

1.3 QUALIFICATION PROCEDURES

- A. The storage, handling, and transportation of all refrigerants, oils, lubricants, etc. shall be accomplished in strict compliance with all State, local, and Federal Regulations including all requirements set forth by the Environmental Protection Agency (EPA) for the safe handling of regulated refrigerants and materials. The Contractor shall utilize qualified and/or certified personnel and equipment as prescribed by these requirements. In no situation shall any refrigerant be discharged to the atmosphere. All refrigerants recovered from all systems shall be returned to the Owner or disposed of in compliance with these same regulations.

PART 2 - PRODUCTS

2.1 AIR COOLED CONDENSER

- A. Furnish and install air cooled condensers located on building roof as shown on the drawings. Air cooled condenser shall be of type and capacity as specified in the Mechanical Equipment Schedule on the drawings.

2.2 PIPING

- A. Refrigerant piping materials and installation shall be in accordance with the best working and piping practices for Freon refrigerants. The Contractor shall install the refrigerant piping using Type "L" hard drawn copper tubing, Federal Specification WW-T-749, with silver solder joint. All piping shall be installed in a straight manner, free from traps, and shall be provided with plugged or capped ends, as it is erected, to prevent dirt from entering. The piping system shall be provided with gauges as required for the operation of the system. The piping is shown schematically on the drawings, verify exact arrangement and pipe sizing with equipment manufacturer.

2.3 VALVES

- A. Expansion valves shall be of the thermostatic type as manufactured by Alco, Sporlan, or equivalent, and shall be gas charged with capillary tube, external superheat adjustment and external equalizing connection. The expansion valves at each apparatus shall be protected by a strainer in the refrigerant liquid line to that group. The strainer shall be as manufactured by the Henry Valve Company, or equivalent, not less than line size and provided with shut-off valves before and after, and furnished with the packaged reciprocating unit.
- B. Solenoid valves shall be suitable for the system in which they are used and shall be designed specifically for use with Freon refrigerants. Solenoid valves shall be furnished with the packaged reciprocating unit.
- C. Refrigerant line valves shall be packless type or packed type with gas tight cap seal with wheel, globe, angle, or "T" needle type, with hard metal seats and shoulders on stems to permit packing stuffing boxes while open under pressure, or sealed diaphragm type.

2.4 DRYER

- A. In each liquid line, install a suitable silica gel filter and dryer. Dryer shall be furnished with the chiller.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Piping installation shall conform to the requirements of Section 23 0500, Common Requirements for HVAC, and Section 23 0504, Pipe and Pipe Fittings.

3.2 TESTING OF REFRIGERANT PIPING SYSTEM

- A. After the installation of the refrigerant piping system has been completed, all piping shall be tested and proven tight for a period of twenty four (24) hours at a pressure of 150 lbs. per square inch using dry nitrogen.

3.3 EVACUATION AND CHARGING

- A. Upon completion of the piping pressure test, the refrigerant circuit shall be evacuated to 500 microns using a closed tube manometer and a high vacuum pump (using an electronic vacuum gauge that reads in microns) to ensure tightness of the piping and to remove air and moisture from the piping system. Upon completion of evacuation and acceptance of the system tightness, the vacuum shall be broken by the introduction of the refrigerant.

3.4 REFRIGERANT AND LUBRICATING OIL

- A. Contractor shall furnish and install all of the refrigerant required to develop the system to its full rating, and in addition to the initial charge, the Contractor shall be required to provide all refrigerant required for the proper operation of the refrigeration apparatus during the first season's operation. Contractor shall guarantee that the loss of refrigerant for a season's operation shall not exceed 10% of the full charge of the system and he shall furnish any refrigerant required above this amount. This guarantee shall remain in effect until such time as the Contractor shall demonstrate this performance for one full year's operation. The Contractor shall be required to provide the initial charge of lubricating oil for all refrigeration apparatus and related equipment, and shall furnish a chart listing the type of oil and a schedule for maintenance that should be used with the various equipment.

3.5 PRESSURE RELIEF DEVICES

- A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15-1994. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.
- B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

END OF SECTION 23 2313

SECTION 23 3000

AIR TEMPERING SYSTEM AND EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Provide all products, labor and services necessary to construct and demonstrate proper functionality of the HVAC and exhaust systems indicated on the drawings and specified herein.
- B. Conform with applicable provisions of the General Conditions, the Supplemental General Conditions and General Requirements.
- C. See Sections 23 0500, 23 0548, 23 0549, 23 0593, 23 0700, and 23 0900 for additional requirements.
- D. Comply with the Equipment General Requirements in Spec Section 23 0500.

1.2 SCOPE

- A. Install control dampers supplied under Section 23 0900. Adjust dampers for smooth operation.

1.3 SUBMITTALS

- A. Submit the following for review and approval:
 - 1. All equipment shown on the equipment schedule and elsewhere on the drawings. Submit evidence or certification that equipment complies with ASHRAE Std. 90.1.
 - 2. Ductwork construction standards, sheet metal, plenums, ductwork accessories, etc.
 - 3. Flues and vents: Materials of construction and accessories. For vents with horizontal offsets or expansion joints, submit layout for review.
 - 4. Dampers for fire and smoke control: For each type of damper proposed, submit manufacturer's literature demonstrating compliance with all aspects of the specifications and drawings. Submit manufacturer's installation instructions.
 - 5. Air Filters and Filter Gauges
 - 6. Grilles, Registers & Diffusers: Configuration, materials of construction, finish, mounting details, and performance data including throw, static-pressure drop, and noise ratings. Submit for type only, but supplier shall check and verify that the indicated diffuser type and sizing are appropriate for each area. Advise of any concerns in any areas.
 - 7. Terminal Units:
 - a. Submit the following for each type of unit: Unit construction, materials, and wiring diagrams.
 - b. Submit the following for each size unit: Dimensional data, recommended flow ranges, and performance data (pressure drop and sound data) at maximum flow.
 - c. Submit a schedule showing the following for each terminal unit indicated on the drawings: Tag number, max & min CFM, size, pressure drop, and heating system performance.

1.4 QUALITY ASSURANCE

A. Component Characteristics

1. All components within ducts and plenums shall be non-combustible or shall have a flame spread less than 25 and smoke developed less than 50 when tested as a composite product per NFPA 255, ASTM E84, or UL 723, except where specifically permitted by the UMC and noted in the drawings or specs.

1.5 SOUND LEVELS

- A. Sound levels attributable to mechanical equipment are designed to result in sound levels of NC 40 for offices, and NC 35 for classrooms, etc., measured within the rooms. Mechanical equipment that has been substituted for the specified equipment shall perform within the specified equipment sound limitations, or will be replaced or adjusted as required. Sound levels attributable to duct vibration that result in noticeable noise or vibration to duct hangers, lighting fixtures, ceiling tees or diffusers shall be re-supported or adjusted until the disturbing noise is brought within acceptable limits.

1.6 DIMENSIONS

- A. Compare all drawings and verify all dimensions both on the drawings and in the field before laying-out, cutting, and fabricating the work.
- B. Refer to Section 23 0500, Common Work Requirements for HVAC, for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 DUCTWORK AND PLENUMS

- A. Materials: Construct all ducts, casings, plenums etc. from galvanized steel sheets except as indicated. Sheets shall be free of blisters, slivers, pits, and imperfectly galvanized spots. Reinforcing angles and bars, and duct support materials shall be same material as ductwork if exposed to the air stream, or galvanized steel if not exposed to the air stream.
1. Galvanized Steel: Per ASTM A653/A653-03 Standard Specification for Steel Sheet, Zinc-Coat (Galvanized) or Zinc-Iron Alloy-Coat (Galvanized) by the Hot Dip Process, with minimum 1.25oz/sf zinc.
 2. Aluminum: Alloy 3003-H14
 3. Stainless Steel: 340SS, provide No. 2B finish in exposed areas
 4. Fiberglass Ductwork (Ductboard): Use only where specifically noted. Minimum 1-inch thick, 3 lb. density rigid fiberglass ductboard with glass fiber reinforced vapor barrier, UL Class 1, labeled on each board per UMC-06 Standard 6-5.
 - a. Properties:
 - 1) Thermal conductivity for 1-inch thickness shall not exceed 0.22 Btuh/SF-F at 75 deg F

- 2) Noise reduction coefficient of 0.80 on Mounting No. 6.
 - b. Tape: 3-inch "Hardcast" mineral impregnated woven fiber tape with an actuator/adhesive applied in accordance with the manufacturer's directions, or thermlok heat sensitive tapes. Pressure sensitive tapes will not be accepted.
 - c. Owens-Corning Fiberglass, Johns Manville, Certain-Teed or equivalent. Flexural rigidity (E.I.) average shall not be less than 475.
- B. Flexible Ducts: Factory fabricated, listed as a Class 1 Air Duct per UL 181 with aluminum foil interior liner, corrosion resistant helix mechanically locked to fabric to ensure dimensional stability, helix separated from air stream, 1.5-inch fiberglass insulation with conductance not to exceed 0.23 Btu-h-in/Hr-SF-F, and fire retardant outer vapor barrier. Ducts shall be rated at 12-inch positive pressure, 5-inch negative pressure, 0.1 perm per ASTM E96, and -20 to +250°F. Flexmaster Type 3, Technaflex 57K, OAE.
- C. Ductwork Accessories
 1. Sealers: Water based, for use on galvanized steel and with the other materials specified herein, suitable for use at -20 to +200°F and duct pressures to 10 inches wg, dry to the touch within 12 hours, sufficiently flexible to pass a 0.25-inch mandrel test, listed per UL-181A & 181B, and suitable for storage and application at 40–110°F. Approved Manufacturers: Carlisle Coatings & Waterproofing "Hardcast," Foster, RCD, AM Conservation Group, OAE.
 2. Tapes: 4" woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal. Water, mold, and mildew resistant for indoor and outdoor service. Sealant shall be modified styrene acrylic.

2.2 SHEET METAL ACCESSORIES

- A. Dampers: Factory fabricated, suitable for use with air at -20 to +240°F, galvanized steel housing and blades except as noted, rated for indicated pressures in either direction and performance rated per AMCA-500.
 1. Shafts: Square or hexagonal steel, 3/8-inch or 1/2-inch, continuous through damper, mechanically fastened to damper blade, and extending through frame as required for actuator or standoff bracket and locking quadrant as required by table below.
 2. Bearings: Provide for each side of each shaft, molded synthetic or stainless steel sleeve type.
 3. Multi-blade dampers: Except as indicated, provide parallel-blade for 2-position applications and opposed blade for modulating applications. Provide jackshafts as required to drive large dampers.
 4. The dampers described in this section are assigned Type Numbers D1 through D23. The following table summarizes key characteristics of each type of damper. Drawings and Part 3 – Execution, indicate which type of damper to use in each application.

Type	Shape	Blade	Max Size (inches)	Multiple Sections	Rated Velocity (FPM)	Rated Shutoff Press. (in. wg)	Seals	Leakage (CFM/SF @ 1 in. DP)	Notes	Ruskin Model
D1	Rect	Flat	36 x 12	No	1500	2.5	No	--	1	MD15
D1	Rect	3V	48 x 48	No	1500	2.5	No	--	1	MD15
D2	Rect	Flat	36 x 12	No	1500	2	No	--	1	MD25
D3	Rect	3V	48 x 48	Yes	1500	2	No	80	1	MD35
D4	Rect	3V	48 x 72	Yes	1500	2.5	No	40		CD35
D5	Rect	3V	48 x 72	Yes	1500	2.5	Yes	4		CD36
D6	Rect	Airfoil	60 x 72	Yes	4000	6	Yes	2	2	CD50
D7	Rect	Airfoil	60 x 72	Yes	4000	6	Yes	2		CD60
D20	Round	Flat	20	No	1500	2	No	40	1	MDSR25
D21	Round	Double	40	No	4000	10	Yes	4		CDR25
D22	Round	Double	24	No	4000	6	Yes	6		CDSR25
D23	Oval	Double	72 x 24	No	4000	10	Yes	4		CDO25

Note 1: Provide locking hand quadrant and 2-inch standoff bracket

Note 2: Aluminum Construction

B. Flexible Connectors: Except as noted flexible connectors shall be heavy fiberglass cloth; coated to be air tight, water tight, fire retardant; suitable for temperatures of -20 to +200° F; rated for 10 in. wg positive or negative; with tensile strength minimum 450 lb/inch in the warp and 340 lb/inch in the filling. Provide flexible connectors in 3-3-3 configuration, with 3-inch galvanized steel strip along each edge and 3-inches of flexible fabric in the center.

1. Standard Applications: Flame spread 20, smoke developed 40, Ventfabrics Ventglas OAE
2. Applications Exposed to Sun and Weather: Double coated with du Pont Hyphalon, Ventfabrics Ventlon OAE.
3. Applications from 200 – 500° F: Tensile Strength 285 lb/inch in the wrap and 185 lb/inch in the filling. Ventfabrics Ventsil OAE
4. Corrosive Applications: Teflon coated, Ventfabrics Ventel OAE.

C. Duct and Plenum Access Doors: Galvanized steel, gasketed. Size as required to properly inspect and service components located within the ductwork. Ruskin, Acudoor, Ductmate, OAE.

1. Rectangular ducts up to 2-inch positive or negative SP: Minimum 22 gauge frame and door thru 12-inch size, 20 gauge door for larger sizes, double gasketed (between door and frame, and between frame and duct) with cam locks, either hinged or removable. Ruskin ADH22, ADC22, ADHW22, or ADCW22, Ventfabrics, OAE
2. Round or Rectangular Ducts to 12-inch Positive Pressure: Removable oval sandwich style with gasketed inner door, insulated outer door, and large hand knobs. Ruskin ADR and ADF.
3. Ducts to 12-inch Negative Pressure: Ruskin ADHP-3.

4. Plenum Access Doors: Factory fabricated frame and door rated to 4-inch positive or 8-inch negative pressure. Provide mill finish and neoprene seals to limit leakage to less than 0.1 CFM/inch perimeter with door closed. Doors shall open against air pressure.
 - a. Frame: Extruded aluminum with 1.5-inch flange and mitered corners
 - b. Door: Extruded aluminum mitered frame, double wall 24-gauge galvanized steel panel with minimum R-5 insulation isolated from the air stream, full-length piano hinge and two heavy-duty latches similar to Ventlok 310.
 - c. Approved Manufacturers: Ruskin GPAD or approved equal.
- D. Turning Vanes:
1. Single wall: Per SMACNA HVAC Duct Construction Standards Figure 2-3 & 2-4.
 2. Double wall: Airfoil shape with smoothly rounded entry nose and extended trailing edge, minimum 2" x 3" vane crosssection, hot dipped galvanized steel, 26-gauge vanes, 24-gauge runner, each vane double pinned to each runner, field adjustable to required elbow aspect ratio. Performance shall not exceed the following for a 24 x 24 elbow at 2000 FPM average: Air pressure drop 0.105 in. wg; sound generated 54 dB re 10⁻¹² watts. Aero/Dyne Co. Model HEP, Airsan, Elgen, or equivalent.
- E. Roof Curbs and Equipment Support Rails: Factory fabricated, minimum 12-inch high, galvanized steel, configured to account for roof pitch where pitch exceeds 1/4-inch/ft or where required by manufacturer of supported equipment. Coordinate with roofer and provide cant and step if needed to match roof construction.
1. Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, OAE.
 2. Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck OAE
- F. Louvers: 4-inch extruded 6063-T5 aluminum alloy frame and blades with flange, mill finish, and 1/2-inch galvanized steel bird screen.
1. Structural: Designed and furnished to carry wind load of not less than 20 psf. Intermediate mullions and supports if provided as part of louver, shall not be visible from the exterior.
 2. Air Pressure Drop: Less than 0.20 in wg at 1000 FPM over free area (8.58 square feet), intake or exhaust per AMCA 500 based on 48 x 48 test sample.
 3. Moisture Penetration: Less than 0.01 oz/sf over 15 minute test per AMCA-500 at 873 FPM intake over free area based on 48 x 48 test sample.
 4. Ruskin ELF375DX OAE.
- G. Acoustic Louvers
1. Ruskin ACL 1245, 12 inches deep, with 45 degree blade angle, 22 percent free area (48" x 48" typical unit with .15 inch w.g. maximum pressure drop, at 4277 cfm air flow). Frame and blade material shall be galvanized steel. Free field noise reduction shall be:

Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
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Reduction (db) 14 13 15 20 23 22 20 20

2. Provide bird-screen, steel channel frame, Ruskatherm blanket insulation, and perforated steel interior surface that covers insulation.

H. Thermometers: As specified in Section 23 0505.

- I. Barometric Pressure Balance Dampers: Air Balance, Inc. units with adjustable counter weight, aluminum air foil design blades, nylon bearings. Match frame assembly to wall or duct.

2.3 FILTERS AND FILTER GAUGES

- A. Rated per ASHRAE Std. 52.1; Class 1 or 2 per UL Std. 900; glass fiber media; suitable for operation from -20° F to +170° F; corrosion resistant; suitable for installation with pleats either horizontal or vertical, and for air flow horizontal, vertical upflow, or vertical downflow; suitable for face velocity up to 625 FPM. Unless specified elsewhere, pre-filters shall be MERV-7, and final filters (where specified) shall be MERV-14. AAF, Camfil Farr, or approved equal.

		MERV RATING						
		7	11	14	11	14	11	14
Description							High Capacity	
Configuration		2-inch or 4-inch	12-inch Cartridge		6-inch Cartridge		12-inch Cartridge	
Initial Resistance	in. wg.	0.26	0.25	0.58	0.39	0.58	0.29	0.49
Rated Velocity	FPM	500	500	500	500	500	500	500
Max Velocity	FPM	625	625	625	625	625	750	750
Recommended Final Resistance	in. wg.	0.7	1.5	1.5	1.5	1.5	1.5	1.5
Gross Media per 24 x 24 Filter	SF	14 Pleats per foot	62	62	105	125	175	175
Housing		Cardboard	Polystyrene or Aluminized Steel	Polystyrene or Aluminized Steel	Polystyrene or Aluminized Steel			
Frame		Channel	Gasketed		Gasketed		Gasketed	
AAF Model		Perfect Pleat	VariCel RF		VariCel M-Pak		VariCel V	
Camfil Farr Model		3030	RigaFlow					

- B. Filter Gauges: Provide a filter gauge for each bank of filters. Gauges shall be magnehelic type with static pressure tips and inter-connecting piping. Ranges shall be 0-1 inch w.g. for all filters except bag filters which shall have a range of 0-2 inches w.g.

2.4 TERMINAL UNITS

- A. General: Factory packaged unit with casing, air valve, air flow sensor. If the following sections are specified or required, provide them as part of the factory package: heating section, fan, and sound attenuator. Terminal units (TUs) shall be suitable for variable volume operation over the scheduled air flow ranges. Air flow and sound performance shall be rated per ARI 880. All materials in the air stream shall comply with the requirements of UL-181 and NFPA-90A.

1. Unit Construction:

- a. Casing: Minimum 22-gauge galvanized steel with round inlet collar, rectangular outlet collar, 3/4-inch acoustic lining with cut edges coated with sealant.
 - b. Air Valve: Heavy gauge metal damper, shaft to extend through casing, self-lubricating bearing, with leakage not to exceed 2% of rated air flow when closed with 3-inch inlet pressure.
 - c. Air Flow Sensor: Cross configuration located at inlet of assembly, accurate to within 5% with 90° elbow directly at inlet connection. Provide
 - d. Sound Attenuator: Galvanized steel with acoustic lining. Provide aluminum liner if specified for casing.
 - e. Heating Section:
 - 1) HW Coils: Copper tubes, aluminum fins, galvanized steel casing, sweat connections, ARI rated, minimum 300 psi rated. Size heating coils for the capacities indicated on the equipment schedule. Provide single row coils wherever they can do the specified heating duty. Provide 2-row coils where indicated and where required for the indicated heating capacity. Do not exceed 0.5-inch static pressure drop for the entire unit (terminal unit, heating coil and sound attenuator). Where necessary to limit pressure drop, either over-size unit or provide a separate, larger (lower pressure drop) heating coil to be installed in the discharge ductwork.
2. Sound Data: The equipment schedules show maximum allowable NC levels based on unit sound power measured per ARI-885, and sound attenuation per ARI-885 Appendix E with a Type 2 ceiling. Do not exceed the scheduled sound levels.
3. Controls: Controls will be supplied by the controls contractor for installation by terminal unit (TU) supplier. Coordinate with controls contractor who will ship controls to TU manufacturer. TU manufacturer shall install controls onto terminal units.
4. Approved Manufacturers: Price, Anemostat, Titus, Krueger, or approved equal.

- B. VAV Reheat: Single duct type with reheat as indicated, Price SDV.

2.5 GRILLES, REGISTERS AND DIFFUSERS

- A. General: Performance rated per ASHRAE Std 70, *Method of Testing for Rating the Performance of Air Outlets and Inlets*, steel with baked white enamel finish except as noted, for installation on a fixed surface or a lay-in T-bar ceiling as indicated on architectural drawings, rigidly constructed, vibration free, with inlet collar of sufficient length to connect inlet ductwork, sized as shown on drawings. Where frames are provided for installation in fixed surfaces, frames shall be approximately 1-1/8" wide. Sound performance rated per ADC and based on room absorption of 10dBre10⁻¹² Watts and one diffuser.

1. Approved Manufacturers: Price, Krueger, Titus, Anemostat, OAE

B. Types as follows. See also the Grille and Diffuser Schedule on drawings.

1. Square Ceiling Diffusers: Louvered type, 4-way pattern, 1-piece smooth aerodynamic surfaces with no corner joints, three louvers for 12-inch sizes, four louvers for 24-inch sizes, removable louver assembly, round neck, to provide stable, horizontal air flow without dumping down to 75 FPM inlet velocity for ceiling applications, and down to 20% of maximum air flow for non-ceiling applications. Price SCD.
2. Ceiling Return, Exhaust and Transfer Grilles: 1/2" x 1/2" x 1/2" egg crate type, steel frame for surface mounting or T-bar ceiling per application, aluminum grid. Price Series 80.
3. Sidewall Supply Registers: Double deflection with ganged horizontal front bars, individually adjustable vertical rear bars, 3/4" bar spacing and surface mounting frame. Price 520.
4. Sidewall Return, Exhaust and Transfer Grilles: Fixed horizontal bars on 3/4" centers set at 30-45 degrees, surface mounting frame. Price 530.

2.6 COILS

- A. Galvanized steel casing, copper tubes and aluminum fins except as noted, with tubes mechanically expanded into fins, circuited to allow completely draining and venting coil, drain and vent connections, with performance rated per ARI . Do not exceed scheduled air or water pressure drops by more than 5 percent.

PART 3 - EXECUTION

3.1 DUCTWORK AND PLENUMS

A. Ductwork

1. Construct ductwork with wall thicknesses and reinforcing per the SMACNA HVAC Duct Construction Standards, Second Edition, 1995, and IMC 2012.
2. Pressure Classes: Construct ductwork to the following pressure classes:

<u>Duct Element Description</u>	<u>Relative Pressure</u>	<u>Pressure Class</u>
From Outside Air Louver to Filter:	N	1"
From Air Handling Unit to Terminal Unit:	P	4"
From Single Zone AHU to Diffuser	P	2"
From Terminal Unit to Diffuser:	P	1"
From Return Grille to Fan:	N	1"
From Return Fan to Relief Louver:	P	1"
From Exhaust Register to Exhaust Fan:	N	2"

3. Minimum thickness for sheet metal ductwork: 26 gauge.
4. Sealing: Seal ductwork and plenums as follows:

-----Seal Class-----
 -----Supply Ducts-----

<u>Location</u>	<u>≤2 in. wg</u>	<u>≥2 in wg</u>	<u>Exhaust</u>	<u>Return</u>
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces including RA Plenums	C	B	B	C

<u>Seal Class</u>	<u>Description</u>
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A	All transverse joint, longitudinal seams and duct wall penetrations.
B	All transverse joints and longitudinal seams.
C	Transverse joints

- a. Apply duct sealer to inside of seams and joints. Do not use pressure sensitive tape as the primary sealant.
5. Clearance to earth: Maintain minimum 4-inch separation between ductwork insulation and earth.
6. Openings in Ductwork: During installation protect the open ends of ducts to prevent debris and dirt from entering.
7. Provide turning vanes in square elbows of low velocity supply and exhaust ductwork.
8. Collars: Where exposed ducts pass through walls, floors, or ceilings, provide a tight-fitting, flanged sheetmetal collar around duct and tight against finished surface to cover opening and present a neat appearance. Lock collar to duct.
9. Cross Breaking: Cross-break low velocity rectangular sheetmetal ducts on all four sides. Cross break sheet metal between standing seams or reinforcing angles. The center of cross break shall be of the required height to assure surfaces being rigid. Do not cross-break high velocity plenum panels.
10. Grilles Registers and Diffusers: Install plumb, affix to general construction as appropriate, make air-tight connection to ductwork, and adjust air flow pattern to achieve appropriate velocities in the occupied zones. Request direction from Engineer if any question exists regarding proper air flow adjustment.
11. Duct Thermometers: Provide thermometers to indicate mixed air, outside air, and supply air of indoor air handling units over 2,500 cfm and where shown on the Drawings.
12. Test Holes: Provide test holes in ducts at locations where testing is required per Section 23 0593 and as requested by the T&B agent. Close test holes with rubber plugs. Reseal all insulated ductwork with the same insulation, jacket and vapor barrier material after T&B is complete.
13. Closure Systems:
 - a. Rigid Air Ducts: Comply with UL 181A – Standard for Closure Systems for Use with Rigid Air Ducts and Air Connectors.
 - b. Flexible Air Ducts: Comply with UL 181B – Standard for Closure Systems for Use with Flexible Air Ducts and Air Connectors.
14. Factory Made Air Ducts: Install in accordance with the terms of their listing and the manufacturer's recommendations.
15. Acoustic Insulation: See Section 23 0700, HVAC Insulation. Fabricate ductwork so the dimensions indicated on the drawings are the clear dimensions for air flow inside the acoustic insulation.
16. Coordination with Building Construction

- a. General: The drawings show the general intended configuration of the ductwork. Provide additional offsets where necessary to coordinate with the building construction or with the work of other disciplines. Transition ductwork as required at no change in contract price. Where this is necessary, submit for review and maintain the indicated flow areas.
- b. Ductwork is frequently routed through bar joists and between bar joists. Coordinate duct locations with joist submittals prior to fabrication.

B. Special Applications

1. Fiberglass Ductwork (Ductboard)

- a. Provide fiberglass ductboard only where specifically indicated on the drawings and in this specification.
 - b. Install per UMC-06 Standard 6-05 – Standard for Installation of Factory-Made Air Ducts and SMACNA Standard 1884-2003 – Fibrous Glass Duct Construction Standard.
 - c. The drawings indicate required clear inside dimensions for air flow.
 - d. Where a duct constructed of ductboard penetrates a wall or floor which requires a fire damper, smoke damper, or fire/smoke damper, install the FD, SMD or FSD in the wall per its listing, make sheet metal connections to the damper if required, and then transition back to ductboard.
2. Exterior Ductwork: Install ductwork as specified herein and insulate per Section 23 0700. Then enclose the exposed top and sides of ductwork with 28 gauge galvanized steel or 26-gauge aluminum to protect the insulation. Repair any damage to the insulation jacket. Slope sheet metal enclosure to shed water.

C. Hangers and Supports

1. Securely support ducts per SMACNA and UMC Table 6-7. Provide support at each concentrated load and at each change in direction. Provide supports on each side of rectangular ducts and equipment. Where vertical ducts pass through floors or roofs, support with angles or other steel members attached to minimum two opposite sides of duct. Size supports to rigidly support the ductwork. Provide lateral support.
2. Hangers for terminal units: Minimum four 1" x 1/8" galvanized steel straps or two angle trapeze supports.
3. Horizontal Round Ducts: 30 inches and larger in diameter: Provide 2" x 2" x 1/8" black steel rolled angle ring on 6-ft centers, and support from angle.

D. Plenums

1. Single Wall Plenums: Shop fabricated minimum 16 gauge galvanized sheet steel. Horizontal and vertical panels are to be fabricated of 2' x 10' sheets. Unless otherwise dimensioned on the Drawings, access door frames are not to exceed 16-3/4 inch width. Where door width exceeds 16-3/4 inches, vertical panels shall be fabricated around 2" x 2" x 1/4" angle. If the plenum height or width exceeds 9 feet, provide a 2-1/2" x 1/8" continuous galvanized steel strip between each horizontal and vertical seam. Provide high velocity cement at each joint during panel assembly. Panels are to be bolted as

shown on the details or tack welded at the Contractor's option; however, enough panels must be bolted to allow removal of equipment from the plenums. Cover interior surfaces with 2-inch thick, acoustical lining.

- a. Plenum Access Doors: Minimum two fastening devices that can be operated on either side of the door; these devices to be readily operated and moving parts to have bronze pins. All parts of the door shall be constructed of galvanized iron and shall be airtight. Latches: "Ventlock" No. 310 OAE.
2. Double Wall Plenums: Factory fabricated, Semco or equivalent. Submit shop drawings for review including overall configuration, construction details, access doors, erection drawings and structural calculations stamped by a registered structural engineer,.
 - a. Factory fabricated, minimum 18 gauge galvanized steel outside, perforated galvanized steel inside, with 2-inch sound insulation between. Plenums downstream of final filters shall have solid inner panel.
 - b. Heat transfer coefficient shall not exceed 0.0575 BTUH/SF-F at 75 deg F mean temperature. Pressure Ratings: 12 in. wg positive and 10 in. wg negative.
 - c. Noise attenuation shall be as follows in decibels, re 10⁻¹² watts.

	OCTAVE BAND							
	1	2	3	4	5	5	7	8
Attenuation, db:	26	30	36	41	34	36	44	37
Noise Absorption Coeff:	0.22	0.39	1.20	1.36	1.03	0.84	0.74	0.68

3.2 DUCTWORK ACCESSORIES

- A. Dampers: Install dampers with shafts horizontal. Locate dampers so that actuators are readily accessible. Verify that dampers operate smoothly.
 1. Manual Dampers (Balancing Dampers): Damper Types D1 through D23 are all suitable for use as manual balancing dampers. Provide locking quadrants.
 2. Automatic Applications: The following damper types may be used for automatic applications: D4, D5, D6, D7, D21, D22 and D23. Provide damper actuators per Section 23 0900.
- B. Flexible Connectors: Provide flexible connectors at locations indicated on the drawings and at the inlet and outlet of each fan directly connected to duct system. Select flexible connectors appropriate for the application. Provide steel spring vibration isolators spanning across flexible connections of isolated fan housings to prevent blow-apart due to horizontal displacement of fan housings.
- C. Access Doors: Provide as required for access to all components located within ductwork. Locate to facilitate access to such components. Size as appropriate. In addition to locations specifically called out on the drawings or elsewhere in these specs, provide access doors at the following: FDs, SMDs, FSDs, instrumentation mounted within ductwork, fan bearings.
- D. Turning Vanes: Provide turning vanes in square elbows of all supply ducts. Single wall turning vanes may be used in ducts up to 1500 FPM and 24-inch vane length. Provide double wall turning vanes in ducts exceeding either of these criteria.

- E. Roof Curbs and Equipment Support Rails: Coordinate the location of roof curbs and rails with the roof structure, ductwork distribution, and other work. Install after roof deck is installed but before roof is insulated. Mount curbs and rails securely to deck per manufacturer's recommendations. Provide counterflashing as required.
- F. Louvers: Coordinate louver size and construction with structural and architectural openings to assure proper fit. Securely fasten louver to internal structural members to withstand a force of 25 lb/sf plus a safety factor of 3.0.
- G. Instrumentation: Install duct thermometers and filter gauges so they are easily readable from the operator level.

3.3 FILTERS AND FILTER GAUGES

- A. Provide one set of MERV-7 temporary filters until testing and balancing is complete. Then immediately before the system is turned over to the Owner at the completion of the project, remove these filters and provide the specified filters.

3.4 TERMINAL UNITS

- A. Install terminal units so that controls and piping components are readily accessible for normal service and maintenance. Provide minimum 3 ft clear in front of control panels.

3.5 GRILLES REGISTERS AND DIFFUSERS

- A. Install grilles, registers & diffusers (GRDs) square with building construction. Mount sidewall GRDs minimum, 3-inches above floor level. If GRDs have provisions to adjust the direction of air flow, submit a written recommendation regarding the best direction for air flows, obtain written approval from the Owner's Representative, and adjust GRDs accordingly.
- B. Verify frame types with architectural RCPs prior to ordering GRDs.

3.6 CLOSEOUT ISSUES

Testing and Balancing: Test and balance the complete air tempering system as specified in Section 23 0593. It is anticipated that the TAB effort will identify some system deficiencies. Work in a cooperative manner to identify the cause of these deficiencies. Where deficiencies are due to defects in installation, or workmanship, repair as required and re-test to demonstrate proper performance.

A. Cleaning

1. All ducts, coils, housing, registers, grilles, fans, etc., shall be clean when installed and shall be kept clean until the system is completed. As the various parts of the system are installed, they shall be wiped or blown clean and openings taped dust-tight with heavy paper or cardboard until the system is completed and ready for testing. At that time all covers and protective wrappings shall be removed. Where one has been torn or previously removed, the duct, coil, register, etc., shall be carefully cleaned of any dirt or dust that has entered the opening.

END OF SECTION 23 3000

SECTION 23 8126

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: two set(s) for each air-handling unit.

2. Gaskets: two set(s) for each access door.
3. Fan Belts: two set(s) for each air-handling unit fan.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Compressor: one year(s) from date of Substantial Completion.
 - b. For Parts: one year(s) from date of Substantial Completion.
 - c. For Labor: one year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Trane, Carrier, Mitsubishi, or approved equivalent.

2.2 INDOOR UNITS (5 TONS OR LESS)

- A. Ceiling Mounted Cassette, Evaporator-Fan Components:
 1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.

2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Enclosure Type: Totally enclosed, fan cooled.
 - d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - a. Pan-Top Surface Coating: Asphaltic waterproofing compound.
6. Air Filtration Section:
 - a. General Requirements for Air Filtration Section:
 - 1) Comply with NFPA 90A.
 - 2) Minimum MERV according to ASHRAE 52.2.
 - 3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Furnish with Low Ambient Kit and Hail Guard.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.

6. Low Ambient Kit: Permits operation down to 45 deg F.
7. Mounting Base: Polyethylene.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- D. Equipment Mounting:
 1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Install ground-mounted, compressor-condenser components on polyethylene mounting base.
 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 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.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 8126

SECTION 26 0500

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General Conditions, Supplemental General Conditions, and Division 1 Specification Sections apply to all Sections of Division 26.
- B. The requirements listed under General Conditions and Supplementary Conditions and the General Requirements are applicable to this section and all subsequent sections of Division 26 and form a part of the contract.

1.2 SUMMARY

- A. This Section includes general administrative and procedural requirements of electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:
 - 1. Submittals
 - 2. Coordination Drawings
 - 3. Record Documents
 - 4. Maintenance Manuals
 - 5. Rough-Ins
 - 6. Electrical Installations
 - 7. Cutting and Patching

1.3 ELECTRICAL DIVISION INDEX

Section 26 0500	Common Work Results for Electrical
Section 26 0502	Electrical Demolition
Section 26 0523	Low Voltage Electrical Power Conductors and Cables
Section 26 0529	Hangers and Supports for Electrical Systems
Section 26 0544	Raceway and Boxes for Electrical Systems
Section 26 0553	Identification for Electrical Systems
Section 26 2813	Fuses
Section 26 2816	Enclosed Switches and Circuit Breakers
Section 26 2913	Enclosed Controllers

1.4 CODES AND PERMITS

- A. Perform electrical work in strict accordance with the applicable provisions of the National Electrical Code, Latest Edition; National Electric Safety Code, Latest Edition; the Uniform International Building Code, Latest Edition as adopted and interpreted by the State of Colorado, City of Pueblo, and the National Fire Protection Association (NFPA Regulations), current adopted edition. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. The Contractor shall hold and save the Engineer free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.
- B. Secure and pay for all permits necessary for performance of the work. Pay for all utility connections unless otherwise specified herein.
- C. The following lists applicable codes and standards that, as a minimum, shall be followed.

Applicable county and state electrical codes, laws and ordinances.

National Electrical Manufacturer's Association Standards

National Electrical Code

National Electrical Safety Code

Underwriters Laboratories, Inc. Standards

American National Standards Institute

American Society for Testing Materials Standards

Standards and requirements of local utility companies

National Fire Protection Association Standards

Institute of Electrical and Electronics Engineers Standards

Insulated Cable Engineers Association

Occupational Safety and Health Act

Uniform Fire Code

Americans with Disabilities Act

Commercial and Industrial Insulation Standards (MICA)

1.5 RECORD DRAWINGS

- A. Maintain a complete and accurate set of marked up blue-line prints showing information on the installed location and arrangement of all electrical work, and in particular, where changes were made during construction. Use red color to indicate additions or corrections to prints, green color to indicate deletions, and yellow color to indicate items were installed as shown. Keep record drawings accurate and up-to-date throughout the construction period. Record drawings may be reviewed and checked by the Engineer during the construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFI's, bulletins, and change orders neatly taped or attached to record drawing set. Transmit drawings to the Engineer at the conclusion of the project for delivery to the Owner's Representative.

1.6 QUALIFICATIONS

- A. All electricians shall be skilled in their respective trade.

1.7 SUBSTITUTIONS

- A. Identification of Division 26 equipment, fixtures, and materials listed within this Specification and in the Equipment Schedules on the drawings, which are identified by manufacturer's name, trade name, and/or model numbers are generally not meant to give preference to any manufacturer, but are provided to establish the design requirements and standards.
- B. Equipment submitted for substitution must fit the space conditions leaving adequate room for maintenance around all equipment. A minimum of 36 inches, or more if required by Code, must be maintained clear in front of all electrical panels, starters, gutters, or other electrical apparatus. Submit drawings showing the layout, size and exact method of interconnection of conduit, wiring and controls, which shall conform to the manufacturer's recommendations and these specifications. The scale of these drawings shall be scale of Contract Drawings. The Contractor shall bear the excess costs, by any and all crafts, of fitting the equipment into the space and the system designated. Where additional labor or material is required to permit equipment submitted for substitution to function in an approved manner, this shall be furnished and installed by the Contractor without additional cost to the Owner.
- C. Equipment submitted for substitution shall be approved in writing by the Owner or his representative and shall be accompanied by the following:
 - 1. A sample of each item submitted for substitution shall accompany the submittal.
 - 2. Provide a unit price quotation with each item intended for substitution. Include a unit price for the specified item and a unit price for the intended substitute item. Provide a total (per item) of the differential payback to the Owner should the intended substitute item be approved as equivalent to that which is specified.
 - 3. Reimburse the Owner for the Architect/Engineer's additional services required to review and process substitutions.

1.8 PRIOR APPROVAL

- A. Requests for proposed substitutions shall be accompanied with catalog and technical data. Actual equipment components and options shall be highlighted and any discrepancies with the specified equipment noted.
- B. Requests for prior approval received after the specified due date will not be considered.
- C. Division 26 prior approval equipment, fixtures, and materials which are submitted as specified herein and accepted will be included in an Addendum. Equipment, fixtures and materials which are accepted under this prior approval process are accepted for bidding purposes only, subject to all requirements, terms, and conditions of the Contract Documents.

1.9 HAZARDOUS CONDITIONS

- A. Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

1.10 DEFINITIONS

- A. Definitions of terms will be found in the National Electrical Code.
- B. Whenever a term is used in this Specification which is defined in the Code, the definition given will govern its meaning in this Specification.
- C. Whenever a technical term is used which does not appear in the Code, the definition to govern its meaning in these Specifications will be found in the Standard Dictionary of Electrical and Electronic Terms, published by the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.
- D. "Provide" means furnish, install, connect and test unless otherwise noted.

1.11 SUBMITTALS

- A. The Contractor shall submit submittal brochures of equipment, fixtures and materials to be furnished under Division 26.
- B. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or are installed in a manner which is not in conformance with the requirement of this Specification and for which the Contractor has not received a written review, removal of the unauthorized materials and installation of those indicated or specified shall be provided at no change in contract amount.
- C. Install equipment in accordance with the manufacturer's recommendations. Provide accessories and components for optimum operation as recommended by the manufacturer.
- D. Costs for the preparation, correction, delivery, and return of the submittals shall be borne by the Contractor.

- E. Complete data must be furnished showing performance, quality and dimensions. No equipment or materials shall be purchased prior to receiving written notification from the Architect/Engineer that submittals have been reviewed and marked either "NO EXCEPTIONS TAKEN" or "EXCEPTIONS AS NOTED." Submittals returned marked "EXCEPTIONS AS NOTED" do not require resubmittal provided that the Contractor agrees to comply with all exceptions noted in the submittal, and so states in a letter to the Architect/Engineer.
- F. Review of Submittals: Submittals will be reviewed with reasonable promptness, but only for conformance with the design concept of the Project and for conformance with the information indicated on the Drawings and stated in the Specifications. Review of a separate item as such will not indicate review of the assembly in which the item functions. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions and quantities, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work. Review shall not relieve the Contractor of responsibility for the equipment fitting within the allotted space shown on the drawings with all clearances required for equipment operation, service and maintenance including a minimum of 3 feet clear in front of all electrical equipment and panels as defined by the National Electrical Code. Any relocation of mechanical and/or electrical equipment, materials and systems required to comply with minimum clearances shall be provided by the Contractor without additional cost under the Contract.
- G. Shop Drawings: Unless the following information is included, shop drawings will be returned unchecked:
 - 1. Cover sheet for each submittal, listing equipment, products, and materials, and referencing data and sections in Specifications and drawings. Clearly reference project name and provide space for a review stamp.
 - 2. Cover sheet shall clearly identify deviations from specifications, and justification.
 - 3. Include all related equipment in a single submittal to allow complete review. Similar equipment may be submitted under a common cover sheet.
 - 4. Size, dimensions, and weight of equipment.
 - 5. Equipment performance under specified conditions, not a copy of scheduled data on drawings.
 - 6. Indicate actual equipment proposed, where data sheets indicate more than one (1) device or equipment.
- H. Use of substitutions reviewed and checked by the Engineer does not relieve the Contractor from compliance with the Contract Documents. Contractor shall bear all extra expense resulting from the use of any substitutions where substitutions affect adjoining or related work required in this Division or other Divisions of this Specification.
- I. If Contractor substitutes equipment for that drawn to scale on the drawings, he shall prepare a $1/4" = 1'-0"$ installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will fit space with adequate clearances for maintenance. This $1/4" = 1'-0"$ fabrication drawing shall be submitted, for review by the Engineer, with the

shop drawing submittals of the substituted. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

1.12 MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 1, Section 017823 - PROJECT CLOSEOUT. In addition to the requirements specified in Division 1, include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.

1.13 USE OF CADD FILES

- A. Under certain conditions, the Contractor will be permitted the use of the Engineer's CADD files for documentation of as-builts, submittals, or coordination drawings.
- B. The Engineer shall be compensated for the time required to format the CADD files for delivery to the Contractor. Such work may include removal of title blocks, professional seals, calculations, proprietary information, etc.
- C. The Contractor shall complete the enclosed License, Indemnity and Warranty Agreement, complete with contractor's name, address, and Contractor's Representative signature prior to request for CADD file usage.

1.14 DRAWINGS AND SPECIFICATIONS

- A. Electrical drawings are diagrammatic, but shall be followed as closely as actual construction and work of the other sections shall permit. Size and location of equipment is drawn to scale wherever possible. Do not scale from electrical drawings.
- B. Drawings and specifications are for the assistance and guidance of the Contractor. Exact locations, distances, and levels will be governed by the building. The Contractor shall make use of data in all the Contract Documents to verify information at the building site.
- C. In any case where there appears to be a conflict between that which is shown on the electrical drawings, and that shown in any other part of the Contract Documents, the Contractor shall notify and secure directions from the Architect.
- D. Drawings and specifications are intended to complement each other. Where a conflict exists between the requirements of the drawings and/or the specifications, request clarification. Do

not proceed with work without direction.

- E. The Architect shall interpret the drawings and the specifications. The Architect's interpretation as to the true intent and meaning thereof and the quality, quantity, and sufficiency of the materials and workmanship furnished there under shall be accepted as final and conclusive.
- F. In the case of conflicts not clarified prior to the bidding deadline, use the most costly alternative (better quality, greater quantity, and larger size) in preparing the bid. A clarification will be issued to the successful bidder as soon as feasible after the award and, if appropriate, a deductive change order will be issued.
- G. Where items are specified in the singular, this division shall provide the quantity as shown on drawings plus any spares or extras indicated on the drawings or in the specifications.
- H. Investigate structural and finish conditions and arrange work accordingly. Provide all fittings, equipment, and accessories required for actual conditions.

1.15 SIMILAR MATERIALS

- A. All items of a similar type shall be products of the same manufacturer.
- B. Contractor shall coordinate among suppliers of various equipment to assure that similar equipment type is product of the same manufacturer.
- C. Examples of similar equipment types include but are not limited to:
 - 1. Power Circuit Breakers
 - 2. Enclosed Case Circuit Breakers
 - 3. Motor Starters
 - 4. Transformers
 - 5. Panelboards
 - 6. Disconnects
 - 7. Fuses

1.16 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.17 GUARANTEE-WARRANTY

- A. The following guarantee is a part of the specifications and shall be binding on the Contractor:

"The Contractor guarantees that this installation is free from ALL defects. He agrees to replace or repair any part of the installation which may fail within a period of one (1) year after date established below, provided that such failure is due to defects in the materials or workmanship or to failure to follow the specifications and drawings. Warranty of the Contractor-furnished equipment or systems shall begin on the date the system or equipment is placed in operation for beneficial use of the Owner or occupancy by the Owner, whichever occurs first; such date to be determined in writing by means of

issuing a 'Certificate of Substantial Completion', AIA Form G704."

- B. The extent of guarantees or warranties by Equipment and/or Materials Manufacturers shall not diminish the requirements of the Contractor's guarantee-warranty to the Owner.

PART 2 - PRODUCTS

2.1 QUALITY OF MATERIALS

- A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of electrical equipment, and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.
- B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

2.2 ALTITUDE RATINGS

- A. Unless otherwise noted, all specified equipment capacities are for an altitude of 4,900 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

2.3 EQUIPMENT REQUIREMENTS

- A. The electrical requirements for equipment specified or indicated on the drawings are based on information available at the time of design. If equipment furnished for installation has electrical requirements other than those indicated on the electrical drawings, make all adjustments to wire and conduit size, controls, over current protection and installation as required to accommodate the equipment supplied. Delineate all adjustments to the drawings reflecting the electrical system in a submittal to the Contract Administrator immediately upon knowledge of the required adjustment.

PART 3 - EXECUTION

3.1 COOPERATION WITH OTHER TRADES

- A. Coordinate all work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and accuracy of all openings.

3.2 DRAWINGS

- A. The electrical drawings show the general arrangement of all lighting, power, special systems, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents shall be considered as part of the work. Coordinate with architectural, mechanical, and structural drawings. Because of the small scale of the electrical drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. Provide all fittings, boxes, and accessories as may be required to meet actual conditions. Should conditions necessitate a rearrangement of equipment, such departures and the reasons therefore, shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No changes shall be made without the prior written approval. All changes shall be marked on record drawings.
- B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.
- C. Installation of all equipment shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearance, as defined by the National Electrical Code (NEC).
- D. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 26 with the associated architectural, structural, and mechanical work than is normally necessary for a more typical facility.
- E. The installation of all concealed electrical systems shall be carefully arranged to fit within the available space without interference with adjacent structural and mechanical systems.

3.3 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical system, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate electrical systems, equipment, and materials installation with all other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in all other building components during progress of construction, to allow for electrical installations.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and

equipment to provide the maximum clearance possible.

7. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
8. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
9. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
10. Install access panel or doors where units are concealed behind finished surfaces.
11. Install systems, materials, and equipment giving right-of-way priority to systems requiring installation at a specified slope.

3.4 FIELD MEASUREMENTS

- A. No extra compensation shall be claimed or allowed due to differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, and shall report any work which must be corrected. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the electrical work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Contractor.

3.5 EQUIPMENT SUPPORT

- A. Provide support for equipment to the building structure. Provide all necessary structures, inserts, sleeves, firestops and hanging devices for installation of equipment. Coordinate installation of devices. Verify with the Architect that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

3.6 PAINTING

- A. All finish painting of electrical systems and equipment will be under "Painting," unless equipment is hereinafter specified to be painted.
- B. All equipment shall be provided with factory applied standard finish, unless otherwise specified.
- C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished to the satisfaction of the Architect.

3.7 SEISMIC SUPPORTS

- A. The Contractor shall be responsible for all anchors and connections for the electrical work to the building structure to prevent damage of equipment and systems due to seismic activity.

3.8 PROTECTION OF MATERIALS AND EQUIPMENT

- A. The Contractor shall be responsible for the protection of all work, materials and equipment furnished and installed under this section of the specifications, whether incorporated in the building or not.
- B. All items of electrical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner approved by the Engineer.
- C. The Contractor shall provide protection for all work and shall be responsible for all damage done to property, equipment and materials. Storage of materials within the building shall be approved by the Owner's Representative prior to such storage.
- D. Conduit openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. At the completion of the work, fixtures, equipment and materials shall be cleaned and polished thoroughly and delivered in a condition satisfactory to the Architect..

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS "Structural Welding Code."

3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.11 APPLICATION OF JOINT SEALERS

- A. General: Comply with joint sealer manufacturer's printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
 - 1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
 - 2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.
- B. Immediately after sealant application and prior to time skinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant

manufacturer.

- C. Firestopping Sealant: Provide sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.12 INSTALLATION OF ACCESS DOORS

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

3.13 CUTTING AND PATCHING

- A. Perform cutting and patching in accordance with Division 1, Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:
 - 1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
 - a. Remove and replace defective Work.
 - b. Remove and replace Work not conforming to requirements of the Contract Documents.
 - c. Remove samples of installed Work as specified for testing.
 - d. Install equipment and materials in existing structures.
 - e. Upon written instructions from the Contracting Officer, uncover and restore Work to provide for Contracting Officer observation of concealed Work.
 - 2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
 - 3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
 - 4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
 - 5. During cutting and patching operations, protect adjacent installations.
 - 6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced installers.

3.14 MANUFACTURER'S INSTRUCTIONS

- A. All equipment shall be installed in strict accordance with recommendations of the manufacturer. If such recommendations conflict with plans and specifications, the Contractor shall submit such conflicts to the Engineer who shall make such compromises as he deems necessary and desirable.

3.15 TESTS

- A. All tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Engineer one week in advance of all tests. The Contractor shall furnish all necessary equipment, materials, and labor to perform the required tests.

3.16 OPERATION AND MAINTENANCE INSTRUCTIONS

- A. The Contractor shall furnish the complete operating and maintenance instructions covering all units of electrical equipment herein specified together with parts lists. Furnish two (2) copies of all the literature; each shall be suitably bound in loose leaf book form.
- B. Operating and maintenance manuals as required herein shall be submitted for review not less than two (2) weeks prior to the date scheduled for the Contractor to provide Operating and Maintenance Instructions to the Owner as specified herein.
- C. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the electrical systems and equipment for a period of five (5) days of eight (8) hours each. During this period, the Contractor shall instruct the Owner or his representative in the operations, adjustment and maintenance of all equipment furnished. Contractor shall provide at least two weeks notice in advance of this period, with a written schedule of each training session, the subject of the session, the Contractors' representatives who plan to attend the session, and the time for each session.

3.17 CERTIFICATIONS

- A. Before receiving final payment, certify in writing that all equipment furnished and all work done is in compliance with all applicable codes mentioned in these specifications. Submit certifications and acceptance certificates to the Engineer, including proof of delivery of O&M manuals, spare parts required, and equipment warranties which shall be bound with O&M manuals.

3.18 INTERRUPTING SERVICES

- A. The Contractor shall coordinate the installation of all work within the building in order to minimize interference with the operation of existing building electrical telephone, fire alarm, and utility systems during construction. Connections to existing systems requiring the interruption of service within the building shall be carefully coordinated with the Owner to minimize system downtimes. Requests for the interruption of existing services shall be submitted in writing a minimum of two (2) weeks before the scheduled date. Absolutely no interruption of the existing services will be permitted without the written review.

3.19 OPERATION PRIOR TO ACCEPTANCE

- A. Operation of equipment and systems installed by the Contractor, for the benefit of the Contractor, except for the purposes of testing and balancing will not be permitted without a written agreement between the Owner and the Contractor establishing warranty and other

responsibilities.

3.20 SITE VISITS AND OBSERVATION OF CONSTRUCTION

- A. The Architect/Engineer will make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the Contractor's work, in order to determine in general if such work is proceeding in accordance with the Contract Documents. This observation by the Architect/Engineer however, shall in no way release the Contractor from his complete responsibility to supervise, direct, and control all construction work and activities, nor shall the Architect/Engineer have authority over, or a responsibility to means, methods, techniques, sequences, or procedures of construction provided by the Contractor or for safety precautions and programs, or for failure by the Contractor to comply with all law, regulations, and codes.

END OF SECTION 26 0500

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL**PROJECT:** _____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for backup and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 26 0502

DEMOLITION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. See Section 260500 for Common Work Results for Electrical.

1.2 SCOPE OF WORK

- A. Provide all material, equipment and labor as required to remove, relocate and/or reconnect all electrical work identified in these specifications and indicated on the drawings.

1.3 SUMMARY

- A. This Section includes limited scope, general construction materials and methods for application with electrical installations as follows:
 - 1. Selective demolition including:
 - a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
 - b. Dismantling electrical materials and equipment made obsolete by these installations.
 - 2. Excavation for underground utilities and services, including underground raceways.
 - 3. Miscellaneous metals for support of electrical materials and equipment.
 - 4. Nailers, blocking, fasteners, and anchorage for support of electrical materials and equipment.
 - 5. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 - 6. Access panels and doors in walls, ceilings, and floors for access to electrical materials and equipment.

1.4 PROJECT CONDITIONS

- A. Conditions affecting selective demolition: The following project conditions apply:
 - 1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
 - 2. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside

demolition limits. When services must be interrupted, install temporary services for affected areas.

B. Conditions affecting excavations: The following project conditions apply:

1. Maintain and protect existing building services which transit the area affected by selective demolition.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
3. Existing utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
4. Remove existing underground utilities indicated to be removed.
 - a. Uncharted or incorrectly charted utilities: Contact utility owner immediately for instructions.
 - b. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Owner's Representative prior to utility interruption.
5. Use of explosives is not permitted.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Verify field measurements and circuiting arrangements as shown on drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents. Report discrepancies to Architect/Engineer before disturbing existing installation.
- D. Beginning of demolition means Contractor accepts existing conditions.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Disconnect and remove electrical systems in walls, floors, and ceilings scheduled for removal.
- B. Coordinate utility service outages with Owner a minimum of 72 hours prior to outage.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing system: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switch overs and connections. Obtain permission from the Owner's Representative at least 72 hours before partially or completely disabling

system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.2 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Demolish and extend existing electrical work under provisions of this section.
- B. Remove, relocate and extend existing installations to accommodate new construction. Recircuit and reconnect all electrical lighting, outlets, and equipment not scheduled for removal that have become disconnected due to demolition work.
- C. Remove abandoned wiring to source of supply.
- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit serving them is removed. Provide blank cover for abandoned outlets which are not removed. Provide blank cover for abandoned outlets which are not removed.
- F. Disconnect and remove abandoned panelboards and distribution equipment.
- G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- H. Disconnect and remove abandoned luminaries. Remove brackets, stems, hangers, and other accessories.
- I. Repair adjacent construction and finishes damaged during demolition and extension work. Any damage to building, piping or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner.
- J. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.
- K. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.
- L. Removal and replacement of ceiling tile(s) to perform work operations shall be the responsibility of the Contractor. The Contractor shall be responsible for replacement of any ceiling tiles or framework that may become damaged at no cost to the Owner
- M. Housekeeping Pads and Equipment Foundations: Remove for all equipment removal. Backfill as required, compact to 95 percent modified Proctor density, and pour floor slab or resurface floor to match existing.
- N. Conduit in Concealed Locations: Remove conductors, cap both ends of conduit, and label conduit as "Abandoned" at both ends. Where conduit runs below grade, cap both ends of conduit and abandon in place. Where conduit runs below floor slab, additionally, chip out

concrete around conduit, remove conduit to bottom of slab level, and patch floor to match existing.

3.3 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment which remain or are to be reused.
- B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.
- C. Luminaries: Remove existing luminaries for cleaning, as indicated on drawings. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.
- D. Materials and equipment to be salvaged: Remove, demount, and disconnect existing electrical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.
- E. Disposal and cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

3.4 INSTALLATION

- A. Install relocated materials and equipment under the provisions of this section.

3.5 ITEMS SALVAGED TO OWNER

- A. Items salvaged to Owner are as indicated on drawings. Move and store in dry location as directed. Refuse materials and items not salvaged shall be removed from the site and legally disposed of.

END OF SECTION 260502

SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

B. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2.

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for **No. 8** AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

END OF SECTION 260519

SECTION 26 0523

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Multimode optical-fiber cabling.
2. UTP cabling.
3. RS-485 cabling.
4. Low-voltage control cabling.
5. Control-circuit conductors.
6. Identification products.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PERFORMANCE REQUIREMENTS

- A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
1. Flame Travel Distance: 60 inches (1520 mm) or less.
 2. Peak Optical Smoke Density: 0.5 or less.
 3. Average Optical Smoke Density: 0.15 or less.
- B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
- C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.4 CONTROL-CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type XHHW-2, in raceway, complying with UL 44.
- B. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 44.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway.

2.5 SOURCE QUALITY CONTROL

- A. Factory test UTP cables according to TIA-568-C.2.
- B. Factory test optical-fiber cables according to TIA-568-C.3.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF RACEWAYS AND BOXES

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
 1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
 2. Flexible metal conduit shall not be used.
- B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
- C. Install manufactured conduit sweeps and long-radius elbows if possible.
- D. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 3 inches (75 mm) above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
4. Cables may not be spliced.
5. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lie on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 30 inches (760 mm) apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

D. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. 12
3. Class 2 low-energy, remote-control, and signal circuits; No. 16.
4. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12.

3.3 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-B, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.4 GROUNDING

- A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

END OF SECTION 260523

SECTION 26 0526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.
 - 3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Burndy; Part of Hubbell Electrical Systems.
 2. Dossert; AFL Telecommunications LLC.
 3. ERICO International Corporation.
 4. Fushi Copperweld Inc.
 5. Galvan Industries, Inc.; Electrical Products Division, LLC.
 6. Harger Lightning and Grounding.
 7. ILSCO.
 8. O-Z/Gedney; A Brand of the EGS Electrical Group.
 9. Robbins Lightning, Inc.
 10. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression -type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 1. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- C. Conductor Terminations and Connections:
 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.

3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- C. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- E. Grounding system will be considered defective if it does not pass tests and inspections.

- F. Prepare test and inspection reports.
- G. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
- H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 26 0529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 ACTION SUBMITTALS

- A. Product Data: For steel slotted support systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 1. Trapeze hangers. Include Product Data for components.
 2. Steel slotted channel systems. Include Product Data for components.
 3. Equipment supports.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 6. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

- a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
- a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
- 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 6. Toggle Bolts: All-steel springhead type.
 - 7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 26 0533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

1.2 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. GRC: Comply with ANSI C80.1 and UL 6.
- C. ARC: Comply with ANSI C80.5 and UL 6A.
- D. IMC: Comply with ANSI C80.6 and UL 1242.
- E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 1. Comply with NEMA RN 1.

2. Coating Thickness: 0.040 inch (1 mm), minimum.
- F. EMT: Comply with ANSI C80.3 and UL 797.
- G. FMC: Comply with UL 1; zinc-coated steel.
- H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel
 - b. Type: Setscrew
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- J. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ENT: Not Applicable
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. LFNC: Comply with UL 1660.
- E. Continuous HDPE: Comply with UL 651B.
- F. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.
- G. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- H. Fittings for LFNC: Comply with UL 514B.

- I. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- J. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.
- C. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- E. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- F. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5.
- C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, **ferrous alloy**, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- F. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- G. Device Box Dimensions: 4 inches square by 2-1/8 inches deep 100 mm square by 60 mm deep.
- H. Gangable boxes are allowed.
- I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- J. Cabinets:
 - 1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC.
 3. Underground Conduit: RNC, Type EPC-40-PVC.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated.
1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums.
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Damp or Wet Locations: GRC.
 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: 1/2-inch (16-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 3. EMT: Use setscrew, compression, steel fittings. Comply with NEMA FB 2.10.
 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- D. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- E. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- F. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- G. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- H. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange raceways to keep a minimum of 1 inch (25 mm) of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
- I. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- K. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

- L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35-mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- N. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- O. Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- P. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.
- Q. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- R. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m).
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F (0.06 mm per meter of length of straight run per degree C) of temperature change for PVC conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- S. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- T. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to **center** of box unless otherwise indicated.
- U. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
- V. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- W. Locate boxes so that cover or plate will not span different building finishes.
- X. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- Y. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- Z. Set metal floor boxes level and flush with finished floor surface.
- AA. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- 3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- 3.4 FIRESTOPPING
- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 26 0544

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 3. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 4. Pressure Plates: Carbon steel.
 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Presealed Systems.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 26 0550

INSTALLATION COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 REQUIREMENTS

- A. See Division 23, Section 230549, HVAC and Electrical Installation Coordination.
- B. See Mechanical Drawings for control requirements and for items requiring 120V power.

PART 2 - PRODUCTS

- A. Not applicable.

PART 3 - EXECUTION

- A. Not applicable.

END OF SECTION 26 0550

SECTION 26 0553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

- ###### A. Product Data:
- For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- ###### A. Comply with ANSI A13.1.
- ###### B. Comply with NFPA 70.
- ###### C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- ###### D. Comply with ANSI Z535.4 for safety signs and labels.
- ###### E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- ###### A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- D. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

- A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- C. Baked-Enamel Warning Signs:
 - 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 - 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - 3. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs:
 - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
 - 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - 3. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.7 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.8 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- F. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 to ground: Install labels at 10-foot (3-m) maximum intervals.

- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
1. Emergency Power.
 2. Power.
 3. UPS.
- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
 - a. Color shall be factory applied.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
1. Comply with 29 CFR 1910.145.
 2. Identify system voltage with black letters on an orange background.
 3. Apply to exterior of door, cover, or other access.
 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
- J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION 260553

SECTION 26 2416

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This section includes panelboards and associated auxiliary equipment rated 600 V and less.
- B. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

1.5 SUBMITTALS

- A. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Include evidence of NRTL listing for series rating of installed devices.
 - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 7. Include wiring diagrams for power, signal, and control wiring.

8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems." Include the following:
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field Quality-Control Reports:
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Panelboard Schedules: For installation in panelboards.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

1.9 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NECA 407.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet.

- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's written permission.
 - 3. Comply with NFPA 70E.

1.12 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.13 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Surface-mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 6. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
 7. Directory Card: Inside panelboard door, mounted in transparent card holder.
- C. Incoming Mains Location: Top and bottom.
- D. Phase, Neutral, and Ground Buses:
1. Material: Tin-plated aluminum.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 3. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Tin-plated aluminum.
 2. Main and Neutral Lugs: Compression type.
 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 6. Gutter-Tap Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 PANELBOARD FABRICATION

- A. Special Features: Include the following features for panelboards as indicated:

1. Hinged Front Cover: The door over the interior of the panel shall be provided with hinge and combination lock and latch. The outside door over the panel gutters shall have a hinge on one side and combination lock and latches

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.4 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Square D; a brand of Schneider Electric.
- C. Panelboards: NEMA PB 1, power and feeder distribution type.
- D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches high, provide two latches, keyed alike.
- E. Mains: Circuit breaker.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers.
- G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Square D; a brand of Schneider Electric.

- C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- D. Mains: Circuit breaker.
- E. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Square D; a brand of Schneider Electric.
- C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
 - e. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - f. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.7 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to **NECA 407**.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to **NECA 407**.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- C. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- D. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.
- E. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- F. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- G. Install filler plates in unused spaces.
- H. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- I. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Labels for identifying the breakers shall be engraved laminated plastic strips attached by screws or Phenolic buttons or small window frame type. Adhesive stick-on labels will not be acceptable.
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."

- C. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- D. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 GROUNDING

- A. Make equipment grounding connections for panelboards or main electrical ground bus as indicated.

3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:

- a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
- b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
- c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

F. Panelboards will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as indicated.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.8 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.9 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 26 2813

FUSES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, enclosed controllers and motor-control centers.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA FU 1 for cartridge fuses.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussmann, Inc.
 - 2. Edison Fuse, Inc.
 - 3. Ferraz Shawmut, Inc.
 - 4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 FUSE APPLICATIONS

- A. Service Entrance: Class L, fast acting.
- B. Feeders: Class L, fast acting.
- C. Motor Branch Circuits: Class RK1, time delay.
- D. Other Branch Circuits: Class RK1, time delay.
- E. Control Circuits: Class CC, fast acting.

3.2 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.3 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.

END OF SECTION 262813

SECTION 26 2816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Enclosures.

1.2 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Lugs: Suitable for number, size, and conductor material.
 - 5. Service-Rated Switches: Labeled for use as service equipment.

2.2 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- C. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- D. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
1. Instantaneous trip.
 2. Long- and short-time pickup levels.
 3. Long- and short-time time adjustments.
 4. Ground-fault pickup level, time delay, and I^2t response.
- F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- G. Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
 2. Lugs: Suitable for number, size, trip ratings, and conductor material.
 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 7. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

2.3 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 3R.
 3. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NECA 1.

3.2 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262816

SECTION 26 2913

ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes the following enclosed controllers rated 600 V and less:
 - 1. Full-voltage manual.
 - 2. Full-voltage magnetic.
 - 3. Multispeed.

1.2 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed controller.
- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 - 3. Configuration: Nonreversing.
 - 4. Surface mounting.
 - 5. Pilot light.
- C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
3. Configuration: Nonreversing.
 4. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
 5. Surface mounting.
 6. Pilot light.
- D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration: Nonreversing.
 4. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button melting alloy type.
 5. Surface mounting.
 6. Pilot light.
- E. Magnetic Controllers: Full voltage, across the line, electrically held.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Configuration: Nonreversing.

4. Contactor Coils: Pressure-encapsulated type.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 5. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 6. Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 7. Bimetallic Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 8. External overload reset push button.
- F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 3. Fusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 4. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 5. MCP Disconnecting Means:
 - a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

- b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
6. MCCB Disconnecting Means:
- a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.

2.2 ENCLOSURES

- A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
- 1. Dry and Clean Indoor Locations: Type 1.
 - 2. Outdoor Locations: Type 3R.
 - 3. Kitchen Areas: Type 4X, stainless steel.
 - 4. Other Wet or Damp Indoor Locations: Type 4.
 - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.3 ACCESSORIES

- A. Push Buttons, Pilot Lights, and Selector Switches: NEMA ICS 5; heavy-duty type; factory installed in controller enclosure cover unless otherwise indicated.
- B. Control Relays: Auxiliary and adjustable time-delay relays.
- C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height, and with disconnect operating handles not higher than 79 inches (2006 mm) above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

- B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness concrete base.
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Seismic Bracing: Comply with requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in each fusible-switch enclosed controller.
- F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."
- G. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- H. Comply with NECA 1.

3.2 IDENTIFICATION

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- C. Tests and Inspections:
 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
 3. Test continuity of each circuit.
 4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
 5. Test each motor for proper phase rotation.
 6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed controllers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Set field-adjustable switches and overload-relay pickup and trip ranges.
- B. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA

Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Construction Manager before increasing settings.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 262913