SECTION 15181

HYDRONIC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes piping, special-duty valves, and hydronic specialties for chilled-water cooling systems; makeup water for these systems; blowdown drain lines; and condensate drain piping.

B. Related Sections include the following:

1. Division 15 Section "Basic Mechanical Materials and Methods" for general piping materials and installation requirements.

2. Division 15 Section "Hangers and Supports" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.

3. Division 15 Section "Valves" for general-duty gate, globe, ball, butterfly, and check valves.

4. Division 15 Section "Meters and Gages" for thermometers, flow meters, and pressure gages.

5. Division 15 Section "Mechanical Identification" for labeling and identifying hydronic piping.

6. Division 15 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

7. Division 15 Section "HVAC Instrumentation and Controls" for temperature-control valves and sensors.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride.

B. PVC: Polyvinyl chloride.

1.4 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Welding and Brazing: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications".

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.6 COORDINATION

A. Piping arrangements shown are diagrammatic and do not show offsets required. Install piping to avoid interference with existing building systems and structural components.

B. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

C. Coordinate pipe sleeve installations for wall penetrations.

D. Coordinate piping installation with, equipment supports, and roof penetrations.

E. Coordinate pipe fitting pressure classes with products specified in related Sections.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

G. Coordinate installation of pipe sleeves for penetrations through exterior walls and roof assemblies. All installations shall maintain existing guarantees and bonds for existing roofing systems. Submit certification indicating compliance.

1.7 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish sufficient chemicals for initial system startup in for preventive maintenance for one year from date of Substantial Completion. Coordinate chemicals with county facility operating personnel.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Calibrated Balancing Valves:
   a. Flow Design, Inc.
   b. Gerand Engineering Company.
   c. ITT Bell & Gossett; ITT Fluid Technology Corp.
   d. Or approved equal.
2. Pressure-Reducing Valves:
   a. Amtrol, Inc.
   b. Conbraco Industries, Inc.
   c. ITT Bell & Gossett; ITT Fluid Technology Corp.
   d. Or approved equal.
3. Safety Valves:
   a. Amtrol, Inc.
   b. Conbraco Industries, Inc.
   c. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
   d. Or approved equal.
4. Expansion Tanks:
   a. Amtrol, Inc.

b. ITT Bell & Gossett; ITT Fluid Technology Corp.

c. Or approved equal.

5. Air Separators and Air Purgers:

a. Amtrol, Inc.

b. ITT Bell & Gossett; ITT Fluid Technology Corp.

c. Or approved equal.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

E. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves".

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

C. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250° F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

D. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250°F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

E. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

F. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

2.5 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225°F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240°F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.

C. Buffer Tanks: Vertical Welded carbon steel, rated for 125-psig working pressure and 375°F maximum operating temperature, with taps in side of tank for inlet and outlet and for temperature gage fitting. Tanks shall be factory tested with taps fabricated and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Include internal baffle and seismically rated mounting legs.

1. Inlet and Outlet Fittings: Flanged.

2. Tank Fittings: Include tank drain and air vent fittings.

D. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375°F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible diaphragm securely sealed into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

E. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 375° F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-½ and larger; threaded blowdown connection. Provide units in full line sizes for full-system flow capacity.

F. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment. Coordinate with county operating personnel.

G. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.

H. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250°F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of ¾-inch misalignment.

PART 3 EXECUTION

3.1 PIPING APPLICATIONS

A. Chilled Water: Use Type L drawn-temper copper tubing with brazed joints.

B. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Gate or ball valves.

2. Throttling Duty: Globe or ball valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor sink. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves on make-up water piping and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS ¾ ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.1% upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports". Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.

2. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.

C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS ¾: Maximum span, 5-ft; minimum rod size, 1/4-inch.

2. NPS 1: Maximum span, 6-ft; minimum rod size, 1/4-inch.

3. NPS 1-½: Maximum span, 8-ft; minimum rod size, 3/8-inch.

4. NPS 2: Maximum span, 8-ft; minimum rod size, 3/8-inch.

5. NPS 2-½: Maximum span, 9-ft; minimum rod size, 3/8-inch.

6. NPS 3: Maximum span, 10-ft; minimum rod size, 3/8-inch.

7. NPS 4: Maximum span, 10-ft; minimum rod size, 1/2-inch.

D. Support vertical runs at roof, at each floor, and at 10-ft intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing.

3.6 HYDRONIC SPECIALTIES INSTALLATION

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

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

C. Install air separators in pump suction lines. Install piping to compression tank in accordance with manufacturer's recommendations. Install drain valve on units NPS 2 and larger.

D. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48-inches above floor. Install feeder in bypass line, off main, using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

E. Install buffer tanks on concrete pad.

1. Support tank from floor structure on concrete pad with sufficient strength to carry weight of tank, piping connections, and fittings, plus weight of a full tank of water.

F. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Coordinate installation of piping connections to Fan Coil units with piping connections furnished with units.

D. Install ports for pressure and temperature gages at coil inlet connections.

3.8 CHEMICAL TREATMENT

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling. Coordinate specific requirements with county operating personnel.

B. Fill system and perform initial chemical treatment.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush system with clean water. Clean strainers.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.

3. Check expansion tanks and buffer tank to determine that they are not air bound and that system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90% of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping".

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

6. Attach calibrated pressure gage and maintain pressure for one hour. There shall be no drop in pressure. If pressure drops, eliminate leaks and retest until there are no leaks.

7. Prepare written report of testing.

3.10 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.

2. Check pump for proper direction of rotation.

3. Set automatic fill valves for required system pressure.

4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).

5. Set temperature controls so all coils are calling for full flow.

6. Check operation of automatic bypass valves.

7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.

8. Lubricate motors and bearings.

3.11 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION

SECTION 15185

HYDRONIC PUMPS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Close-coupled, end-suction centrifugal pumps.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.4 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements".

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.7 COORDINATION

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

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers:

1. Armstrong Pumps Inc.

2. Bell & Gossett; Div. of ITT Industries.

3. PACO Pumps.

4. Peerless Pump; a Member of the Sterling Fluid Systems Group.

5. Or approved equal.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225°F.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.

3. Pump Shaft: Stainless steel.

4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.

5. Pump Bearings: Permanently lubricated ball bearings.

6. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; rigidly mounted to pump casing with integral pump support. TEFC NEMA Design B with 1.15 service factor.

D. Capacities and Characteristics: As Indicated.

1. Electrical Characteristics: As indicated.

a. Provide Variable Frequency Drive.

b. All components exposed to the weather shall be weatherproof.

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, 175-psig pressure rating, cast or ductile-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 15 Section "Basic Mechanical Materials and Methods".

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around full perimeter of 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.

B. Cast-in-place concrete materials and placement requirements are specified in Division 3.

3.3 PUMP INSTALLATION

A. Comply with HI 1.4 or HI 2.4. As Applicable.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Set pumps on concrete foundation with metal spring vibration isolation system and seismic restraints. Align piping with pump connections so that no piping weight is supported by pumps.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to pumps. Install valves that are same size as piping. Provide reducing fittings for connections to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check valve, throttling valve and shutoff valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve. Connect gage to also measure pressure loss across suction diffuser.

I. Install VFD and electrical connections for power, controls, and devices in accordance with Division 16.

J. Ground equipment according to Division 16 Section "Grounding System".

K. Connect wiring according to Division 16 Section "Wire and Cable - 600 Volts and Under".

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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

2. Check piping connections for tightness.

3. Clean strainers on suction piping.

4. Perform the following startup checks for each pump before starting:

a. Verify bearing lubrication.

b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

6. Start motor.

7. Open discharge valve slowly.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Division 1 Section "Closeout Procedures".

END OF SECTION

SECTION 15628

SCROLL WATER CHILLERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Packaged, air-cooled, electric-motor-driven, scroll water chillers.

2. Packaged refrigerant recovery units.

3. Scroll Water Chillers are designated as Owner Furnished and Contractor Installed Equipment.

1.3 DEFINITIONS

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

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

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Scroll water chillers 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."

1.5 SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at ARI standard conditions and at conditions indicated.
2. Performance at ARI standard unloading conditions.
3. Minimum evaporator flow rate.
4. Refrigerant capacity of water chiller.
5. Oil capacity of water chiller.
6. Fluid capacity of evaporator.
7. Characteristics of safety relief valves.
8. Minimum entering condenser-air temperature
9. Performance at varying capacity with constant design entering condenser-air temperature. Repeat performance at varying capacity for different entering condenser-air temperatures from design to minimum in 10°F increments.

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

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

C. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

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

E. Seismic Qualification Certificates: For water chillers, accessories, and components from manufacturers.

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.

F. Source quality-control test reports.

G. Startup service reports.

H. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

B. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

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

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

E. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes, locations, and anchoring attachments of existing structural-steel support structures.

1.9 WARRANTEE

A. Provide manufacturer's extended warrantee renewable on a yearly basis for a period of up to five years from date of startup and acceptance of chiller.

PART 2 PRODUCTS

2.1 PACKAGED AIR-COOLED WATER CHILLERS

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

1. Carrier Corporation; a United Technologies company.

2. York International Corporation. (Johnson Controls).

3. Or approved equal.

B. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

C. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.

D. Cabinet:

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

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

3. Casing: Galvanized steel.

4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.

5. Sound-reduction package consisting of the following:

a. Acoustic enclosure around compressors.

b. Vertical Discharge fans with low noise fans with acoustic airfoil design.

c. Designed to reduce sound level without affecting performance.

E. Compressors:

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

2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.

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

4. Capacity Control: On-off compressor cycling, plus hot-gas bypass.

5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.

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

F. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.

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

G. Compressor Motor Controllers:

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

H. Refrigeration:

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

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

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

4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

5. Provide a minimum of 2 independent refrigeration circuits.

I. Evaporator:

1. Shell-and-tube design, as indicated.

2. Shell and Tube:

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

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

c. Shell Material: Carbon steel.

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

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

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

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

J. Air-Cooled Condenser:

1. Plate-fin coil with integral subcooling on each circuit, rated at 650 psig.

a. Construct coils of a single material to avoid galvanic corrosion.

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

3. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

4. Fan Guards: Steel safety guards with corrosion-resistant coating.

K. Electrical Power:

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

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

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

4. Install factory wiring outside of an enclosure in a raceway.

5. Field power interface shall be to wire lugs.

6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.

b. NEMA KS 1, heavy-duty, nonfusible switch.

c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

7. Provide each motor with overcurrent protection.

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

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

10. Provide power factor correction capacitors to correct power factor to 0.90 to 0.95 at full load.

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

a. Power unit-mounted controls where indicated.

12. Control Relays: Auxiliary and adjustable time-delay relays.

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

a. Current, phase to phase, for all three phases.

b. Voltage, phase to phase and phase to neutral for all three phases.

c. Three-phase real power (kilowatts).

d. Power factor.

e. Running log of total power versus time (kilowatt hours).

f. Fault log, with time and date of each.

L. Controls:

1. Stand-alone, microprocessor based control system capable of controlling the chiller unit, a future chiller unit, the distribution pumps including VFDs,

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

3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

a. Date and time.

b. Operating or alarm status.

c. Operating hours.

d. Outside-air temperature if required for chilled-water reset.

e. Temperature and pressure of operating set points.

f. Entering and leaving temperatures of chilled water.

g. Refrigerant pressures in evaporator and condenser.

h. Saturation temperature in evaporator and condenser.

i. No cooling load condition.

j. Elapsed time meter (compressor run status).

k. Pump status.

l. Anti-recycling timer status.

m. Percent of maximum motor amperage.

n. Current-limit set point.

o. Number of compressor starts.

4. Control Functions:

a. Manual or automatic startup and shutdown time schedule.

b. Entering and leaving chilled-water temperatures, control set points, and motor load limit.

c. Current limit and demand limit.

d. External water chiller emergency stop.

e. Anti-recycling timer.

f. Automatic lead-lag switching and control for future second chiller unit as well as pumps

5. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset. (Shutdown of chiller shall register an alarm condition and shall automatically start the redundant backup chiller.)

a. Low evaporator pressure or high condenser pressure.

b. Low chilled-water temperature.

c. Refrigerant high pressure.

d. High or low oil pressure.

e. High oil temperature.

f. Loss of chilled-water flow.

g. Control device failure.

6. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.

a. Future Hardwired Points:

1) Monitoring: On/off status, common trouble alarm electrical power demand (kilowatts).

2) Control: On/off operation.

b. LonTalk communication interface with future building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

M. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.

2. Thickness: 3/4 inch minimum. Provide additional thickness when required to prevent condensation.

3. Factory-applied insulation over cold surfaces of water chiller components.

a. Adhesive: As recommended by insulation manufacturer and applied to 100% of insulation contact surface. Seal seams and joints.

4. Apply protective coating to exposed surfaces of insulation.

N. Accessories:

1. Factory-furnished, chilled-water flow switches for field installation.

2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.

O. Capacities and Characteristics as Indicated and as Follows:

1. Low Ambient Operation: Chiller designed for operation to 15°F.

2. High Ambient Operation: Chiller designed for operation to 115°F.

3. Evaporator Configuration: Integral to chiller.

4. Evaporator Pressure Rating: 150 psig waterside; 450 psig refrigerant side.

5. Evaporator Fluid Type: Water.

6. Evaporator Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.

7. Site Altitude: 900 feet.

8. Number of Independent Refrigeration Circuits: Two.

9. Controls Power Connection: Fed through integral transformer.

10. Noise Rating: 65 dBA at 30 feet when measured according to ARI 370.

2.2 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

1. Allow Owner Representative access to place where water chillers are being tested. Notify Owner 14 days in advance of testing.

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

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

E. Submit test reports.

PART 3 EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.2 WATER CHILLER INSTALLATION

A. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 3 Section "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of 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.

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

C. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

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

3.3 CONNECTIONS

A. Comply with requirements in Division 15 Section "Hydronic Piping" Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve. Make connections to water chiller with a flange. Provide additional components as indicated.

D. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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

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

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.

2. Verify that pumps are installed and functional.

3. Verify that thermometers and gages are installed.

4. Operate water chiller for run-in period.

5. Check bearing lubrication and oil levels.

6. Verify proper motor rotation.

7. Verify and record performance of chilled- and condenser-water flow and low-temperature interlocks.

8. Verify and record performance of water chiller protection devices.

9. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

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

3.5 DEMONSTRATION

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

END OF SECTION

SECTION 15734

FAN COIL UNITS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Ceiling and below ceiling mounted chilled water fan coil units.

1.3 DEFINITION

A. BAS: Building automation system.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fan Coil Units 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 and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fan coil units 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 and Control Diagrams: For power, signal, and control wiring.

C. Color Samples: For unit cabinet and accessories for each color and texture specified.

D. Coordination Drawings: Plans, elevations, and other details, drawn to scale using input from Installers of the items involved.

E. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.

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.

F. Field quality-control reports.

G. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

H. Warranty: Sample of special warranty.

1.6 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.

1.7 COORDINATION

A. Coordinate installation of fan coil units with existing ceiling arrangements and computer racks, ductwork, conduit and cable trays above and below ceilings.

PART 2 PRODUCTS

2.1 Manufacturers

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In the Fan-Coil-Unit Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2. Basis-of-Design Product: The design for each fan-coil unit is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 Fan-Coil Units

A. Manufacturers:

1. Carrier Corporation.

2. First Co.

3. YORK International Corporation.

4. Or approved equal.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: coated glass fiber or matte-finish, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

D. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner formed to slope from all directions to the drain connection as required by ASHRAE 62.

E. Chassis: Galvanized steel where exposed to moisture.

F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Owner.

1. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral discharge grilles.

2. Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Glass Fiber Treated with Adhesive: 80% arrestance and 5 MERV.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220°F. Include manual air vent and drain valve.

I. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal with direct or belt drive as indicated, and motor.

2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board.

3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Control devices and operational sequences are specified in Division 15 Sections "HVAC Instrumentation and Controls".

K. Basic Unit Controls:

1. Control voltage transformer.

2. Wall-mounting thermostat with the following features:

a. Concealed set point.

b. Concealed indication.

c. Degree F indication.

3. Data entry and access port.

a. Input data includes room temperature, set points and occupied and unoccupied periods.

b. Output data includes room temperature, operating mode, and status.

L. DDC Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.

2. Hydronic-Cooling-Coil Operation:

a. Occupied Periods: Modulate control valve to maintain room temperature.

3. Controller shall have volatile-memory backup.

M. BAS Interface Requirements:

1. Interface relay for scheduled operation.

2. Interface relay to provide indication of fault at the central workstation.

3. Provide LonWorks interface for central BAS workstation for the following functions:

a. Adjust set points.

b. Fan-coil-unit start, stop, and operating status.

c. Data inquiry, including room-air temperature.

d. Occupied and unoccupied schedules.

N. Electrical Connection: Factory wire motors and controls for a single electrical connection.

O. Capacities and Characteristics:

2.3 FAN MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

B. Motors shall be compatible with the Fan control requirements.

2.4 CONDENSATE DRAIN PUMP UNITS

A. Provide packaged condensate drain pump for each fan coil unit. Pumping units shall include integral support attachments, level control, reservoir tank, and pump sized for minimum of 150% of the unit total capacity.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

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

3.2 INSTALLATION

A. Install fan coils level and plumb, maintaining manufacturer's recommended clearances. Coordinate installation with existing access flooring system and conduits/cabling systems located below the floor.

B. FC-Unit Mounting: Install using elastomeric vibration isolation units.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Water and Drainage Connections: Provide connections for chilled water, humidifier make-up water, condensate drain, and humidifier flushing system. Route condensate drains to approved receptor. Route overflow condensate drains to visible ceiling location. Coordinate specific location with the County.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.

2. After installing FC-Units and after electrical circuitry has been energized, test for compliance with requirements.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

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

C. Units will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. After startup service and performance test, change filters.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION

SECTION 15815

METAL DUCTS

PART 1 GENERAL

1.1 Related Documents

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

1.2 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 4-inch wg. Metal ducts include the following:

1. Rectangular ducts and fittings.

2. Duct liner.

B. Related Sections include the following:

1. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

1.4 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Owner's Representative. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

A. Duct Liner

B. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Comply with the more restrictive requirements of these specifications and the project design drawings or SMACNA requirements.

C. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 DUCT LINER

A. Fibrous-Glass Acoustical Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.

1. Manufacturers:

a. CertainTeed Corp.; Insulation Group.

b. Johns Manville International, Inc.

c. Owens Corning.

d. Or approved equal.

2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.

a. Thickness: 1/2 inch.

b. Thermal Conductivity (k-Value): 0.26 at 75°F mean temperature.

c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.

2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.

3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.4 SEALANT MATERIALS

A. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

B. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

C. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers: Electrogalvanized, all-thread rods or galvanized rods.

2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

2.6 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Manufacturers:

a. Ductmate Industries, Inc.

b. Nexus Inc.

c. Ward Industries, Inc.

d. Or approved equal.

2. Duct Size: As indicated and up to 2-inch wg pressure class.

3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with 100% adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to all transverse edges of liner that do not receive metal nosing.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

E. Apply adhesive coating on longitudinal seams in ducts.

F. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

G. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

1. Line all ducts larger than 24-inches in any direction and at other locations where indicated.

H. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

1. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23%.

2.8 ROUND DUCT AND FITTING FABRICATION

A. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter.

PART 3 EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts for OSA Fan-units: 2-inch wg.

2. Return Ducts (Negative Pressure): 1-inch wg.

B. All ducts sizes shown are net inside dimensions.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. The maximum change in direction allowed for a duct offset is 15° unless specifically approved in writing by the Owner's Representative.

C. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

D. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

E. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

F. Coordinate layout with existing construction including suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

G. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

H. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

I. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories."

J. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

K. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

L. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

M. Install duct liner for rectangular plenums and rectangular ducts connecter to CRAC Unit return air duct connections.

3.3 SEAM AND JOINT SEALING

A. Seal transverse and longitudinal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

C. For flexible duct, install powder-actuated concrete fasteners after concrete is placed and completely cured.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."

3.6 FIELD QUALITY CONTROL

A. Perform the field tests and inspections for test and balance according to Section "Testing, Adjusting, and Balancing " and prepare test reports:

END OF SECTION

SECTION 15820

DUCT ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.
2. Volume dampers.
3. Fire dampers.
4. Turning vanes.
5. Duct-mounting access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Duct accessory hardware.

B. Related Sections include the following:

1. Division 15 Section "HVAC Instrumentation and Controls" for electric and pneumatic damper actuators.

1.2 SUBMITTALS

A. Product Data: For the following:

1. Fire dampers.
2. Flexible connectors.
3. Flexible ducts.

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

1. Special fittings including return air ducts connected to CRAC Units.
2. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
3. Wiring Diagrams: Power, signal, and control wiring.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

2.3 VOLUME DAMPERS

A. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

B. Standard Volume Dampers: Multiple- or single-blade, opposed-blade design, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

C. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.4 FIRE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.

2. Greenheck.

3. Ruskin Company.

4. Or approved equal.

B. Fire dampers shall be labeled according to UL 555.

C. Fire Rating: 1-1/2 or 3 hours.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.

2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Fusible Links: Replaceable, 212°F rated.

2.5 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

E. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.6 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Duro Dyne Corp.

2. Ventfabrics, Inc.

3. Or approved equal.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Select metal compatible with ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 24 oz./sq. yd.

2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.

3. Service Temperature: Minus 50 to plus 250°F.

2.7 FLEXIBLE DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc.

2. Hart & Cooley, Inc.

3. McGill AirFlow Corporation.

4. Or approved equal.

B. Insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.

3. Temperature Range: Minus 20 to plus 175°F.

C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or Nylon strap, in sizes 3 through 18 inches to suit duct size.

PART 3 EXECUTION

3.1 APPLICATION AND INSTALLATION

A. All duct sizes shown are net inside dimensions.

B. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.

C. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff. All manual dampers to be installed and secured in place in the full-open position.

F. Provide test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.

H. Install duct access doors of adequate size to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.

I. Label access doors according to Division 15 Section "Mechanical Identification."

J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

K. Flexible ductwork is to be installed with a minimum turning radius of 1-1/2 times the inner duct diameter. The radius is to be measured along the inside bend (on exterior surface) of the duct.

L. Connect flexible ducts to metal ducts with adhesive plus draw bands.

M. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 15 Section "Testing, Adjusting, and Balancing."

END OF SECTION

SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers and grilles.

B. Related Sections include the following:

1. Division 15 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

2. Grille and Register Schedule: Indicate Drawing designation, room location, quantity, model number, size, deflection, and accessories furnished for each diffuser.

B. Coordination Drawings: Provide Coordination Drawings indicating specific locations of existing ceiling and wall support structures and arrangements for diffuser and grille installations.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 DIFFUSERS, GRILLES AND REGISTERS

A. Adjustable Bar Grille/Register:

1. Manufacturers:

a. Anemostat; a Mestek Company.

b. Krueger.

c. METALAIRE, Inc.; Metal Industries Inc.

d. Titus.

e. Or approved equal.

2. Material: Aluminum.

3. Finish: Baked enamel.

4. Face Blade Arrangement: Fixed horizontal spaced 1/2 inch apart.

5. Frame: 1-inch or 1.25-inch wide.

6. Mounting: Concealed.

7. Damper Type: Not required.

8. Accessories: Rear-blade gang operator.

B. Ceiling Diffusers and Grilles

1. Manufacturers:

a. Anemostat; a Mestek Company.

b. Krueger.

c. METALAIRE, Inc.; Metal Industries Inc.

d. Titus.

e. Or approved equal.

2. Material: Aluminum.

3. Finish: Baked enamel off-white.

4. Face Style Arrangement: 4-modual louvered face with adjustable deflection.

5. Frame: Surface or T-bar to match ceiling.

6. Mounting: Concealed.

7. Damper Type: OBD.

8. Accessories: Perforated face for grilles only.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

C. Coordinate mounting frames with ceiling and wall systems.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Owner's Representative for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 15900

HVAC INSTRUMENTATION AND CONTROLS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1. Division 15 Section "Meters and Gages" for measuring equipment that relates to this Section.

2. Division 15 Section "Testing, Adjusting and Balancing" for requirements that relate to this Section.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.3 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

2. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

3. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

4. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

5. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

6. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

   a. Water Temperature: Plus or minus 1°F.

   b. Water Flow: Plus or minus 5% of full scale.

   c. Water Pressure: Plus or minus 2% of full scale.

   d. Space Temperature: Plus or minus 1°F.

   e. Ducted Air Temperature: Plus or minus 1°F.

   f. Outside Air Temperature: Plus or minus 2°F.

   g. Temperature Differential: Plus or minus 0.25°F.

   h. Relative Humidity: Plus or minus 5%.

   i. Electrical: Plus or minus 5% of reading.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

   1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

   2. Control System Software: Include technical data for operating system software, operator interface, and other third-party applications.

   3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including a schematic diagram.

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

   1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

3. Wiring Diagrams: Power, signal, and control wiring.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Detailed written description of sequence of operation including the specified sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. DDC System Hardware:

   a. Wiring diagrams for control units with termination numbers.

   b. Schematic diagrams and floor plans for field sensors and control hardware.

   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

10. Controlled Systems:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

    c. Include sequence of operation and schematic diagram.

    d. Points list.

C. Fan Coil Units: Provide full monitoring and control for all fan coils and central plant equipment provided under this contract. Include the following in addition to other specified requirements:

1. Integrate system control with chiller control system.

2. Software operating and upgrade manuals.

3. Program Software Backup: On a magnetic media or compact disc, complete with data files.

4. Device address list.

5. Printout of software application and graphic screens.

6. Software license required by and installed for DDC workstations and control systems.

7. Start/Stop and temperature reset of chiller with monitoring operation and alarm functions.

D. Qualification Data: For Installer and manufacturer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Project Closeout," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.

2. Interconnection wiring diagrams with identified and numbered system components and devices.

3. Keyboard illustrations and step-by-step procedures indexed for each operator function.

4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

5. Calibration records and list of set points.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.7 COORDINATION

A. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate equipment with Division 16 to achieve compatibility of communication interfaces.

D. Coordinate equipment with Division 15 and 16 to achieve compatibility with motor starters, VFDs, and annunciation devices.

E. Coordinate with Division 15 Section "Testing, Adjusting and Balancing" to allow the balancing agency to complete the balance work for the project. Provide support necessary for balancing agency to accomplish the required balancing.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.8 EXTRA MATERIALS

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

1. One handheld device with software to allow Owner's maintenance technicians to plug into thermostats and troubleshoot local devices. Palm Pilot or equivalent.

PART 2 PRODUCTS

2.1 REQUIREMENTS

A. System: Open Protocol LonWorks.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network.

2.2 DDC EQUIPMENT

A. Operator Workstation: One PC-based microcomputer(s) with minimum configuration as follows:

1. Motherboard: With 8 integrated USB 2.0 ports, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.

2. Processor: Intel Pentium 4 MHz.

3. Random-Access Memory: 512 MB.

4. Graphics: Video adapter, minimum 1600 x 1200 pixels, 64-MB video memory, with TV out.

5. Monitor: 19 inches, LCD color.

6. Keyboard: QWERTY, 105 keys in ergonomic shape.

7. Floppy-Disk Drive: 1.44 MB.

8. Hard-Disk Drive: 80 GB.

9. CD-ROM Read/Write Drive: 48x24x48.

10. Mouse: Three button, optical.

11. Uninterruptible Power Supply: 2 kVa.

12. Operating System: Microsoft Windows 7 Professional with high-speed Internet access.

    a. ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

    b. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

13. Printer: Black-and-white, laser-jet type as follows:

    a. Print Head: 1200 x 1200 dpi resolution.

    b. Paper Handling: Minimum of 250 sheet trays.

    c. Print Speed: Minimum of 120 characters per second.

14. Application Software:

    a. I/O capability from operator station.

    b. System security for each operator via software password and access levels.

    c. Automatic system diagnostics; monitor system and report failures.

    d. Database creation and support.

    e. Automatic and manual database save and restore.

    f. Dynamic color graphic displays with up to 10 screen displays at once.

    g. Custom graphics generation and graphics library of HVAC equipment and symbols.

h. Alarm processing, messages, and reactions.

i. Trend logs retrievable in spreadsheets and database programs.

j. Alarm and event processing.

k. Object and property status and control.

l. Automatic restart of field equipment on restoration of power.

m. Data collection, reports, and logs. Include standard reports for the following:

1) Current values of all objects.

2) Current alarm summary.

3) Disabled objects.

4) Alarm lockout objects.

5) Logs.

n. Custom report development.

o. Utility and weather reports.

p. ASHRAE Guideline 3 report.

q. Workstation application editors for controllers and schedules.

r. Maintenance management.

15. Custom Application Software:

a. English language oriented.

b. Allow development of independently executing program modules with debugging/simulation capability.

c. Support conditional statements.

d. Support floating-point arithmetic with mathematic functions.

e. Contains predefined time variables.

B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

   a. Global communications.

   b. Discrete/digital, analog, and pulse I/O.

   c. Monitoring, controlling, or addressing data points.

   d. Software applications, scheduling, and alarm processing.

   e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

   a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.

   b. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.

   c. Remote communications from campus Ethernet backbone

   d. Maintenance management.

   e. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

5. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

C. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.

5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.

6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.

7. Universal I/Os: Provide software selectable binary or analog outputs.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80% of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1% line and load regulation with 100-mic.sec. response time for 50% load changes.

3. Built-in overvoltage and overcurrent protection and be able to withstand 150% overload for at least 3 seconds without failure.

F. Uninterruptible Power Supply, (UPS): Provide and install a UPS device (Tripp Lite BC Personal or equal) with sufficient battery energy to power the control device for a minimum of 5 minutes. UPS to be provided for workstations and all main control cabinets so that on a loss of power, the entire control system will continue to operate.

G. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.

2. Maximum response time of 10 nanoseconds.

3. Minimum transverse-mode noise attenuation of 65 dB.

4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.3 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.

3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

4. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.

5. Enclosure: Dustproof rated for operation at 32 to 120°F.

6. Enclosure: Waterproof rated for operation at 40 to 150°F.

B. RTDs and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.

b. MAMAC Systems, Inc.

c. RDF Corporation.

d. Or approved equal.

2. Accuracy: Plus or minus 0.2% at calibration point.

3. Wire: Twisted, shielded-pair cable.

4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.

5. Averaging Elements in Ducts: 18 inches long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.

6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.

7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

8. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. Pressure Transmitters/Transducers:

1. Manufacturers:

a. BEC Controls Corporation.

b. General Eastern Instruments.

c. MAMAC Systems, Inc.

d. ROTRONIC Instrument Corp.

e. TCS/Basys Controls.

f. Vaisala.

g. Or approved equal.

2. Accuracy: 2% of full scale with repeatability of 0.5%.

a. Output: 4 to 20 mA.

b. Building Static-Pressure Range: 0- to 0.25-inch wg.

c. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.4 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175% of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1% full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2% error at 1.0 power factor and 2.5% error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Manufacturers:

a. VERIS

b. KELE, Inc.

c. Or approved equal.

2.5 PIPE FLOW STATION

A. Manufacturers:

1. FESXIMclamp-on Ultrasonic BTU Meter.

2. Or approved equal.

2.6 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

2. Nonspring-Return Motors for Valves Larger than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

3. Spring-Return Motors for Valves Larger than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.

4. Nonspring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

5. Spring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

a. Johnson Controls, Inc.

b. Belimo Aircontrols (USA), Inc.

c. Or approved equal.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.

3. Dampers: Size for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.

e. Dampers with 2- to 3-inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

f. Dampers with 3- to 4-inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.

5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.

7. Power Requirements (Two-Position Spring Return): 120-V ac.

8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

10. Temperature Rating: Minus 22 to plus 122°F.

11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250°F.

12. Run Time: 30 seconds.

2.7 CONTROL VALVES

A. Manufacturers:

1. Johnson Control, Inc.

2. Bray Belimo.

3. Or approved equal.

B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

C. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.

2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.

b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:

a. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.

b. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system (pump) head for two-way valves and 100% of pressure differential across valve or 100% of total system (pump) head.

D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250° operating conditions.

2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.

3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that piping and ductwork and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats where required to avoid damage.

E. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."

F. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 16.

B. Install building wire and cable according to Division 16.

C. Install signal and communication cable according to Division 16.

1. Plenum rated cable is acceptable in concealed spaces. Install exposed cable in raceway.

2. Install concealed cable in raceway.

3. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

4. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

5. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

6. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check instrument tubing for proper fittings, slope, material, and support.

5. Check installation of air supply for each instrument.

6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

8. Check temperature instruments and material and length of sensing elements.

9. Check control valves. Verify that they are in correct direction.

10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.

11. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.

    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.

    c. Verify that spare I/O capacity has been provided.

    d. Verify that DDC controllers are protected from power supply surges.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100% of span.

    b. Check analog outputs using milliampere meter at 0, 50, and 100% output.

    c. Check digital inputs using jumper wire.

    d. Check digital outputs using ohmmeter to test for contact making or breaking.

e. Check resistance temperature inputs at 0, 50, and 100% of span using a precision-resistant source.

5. Flow:

a. Set differential pressure flow transmitters for 0 and 100% values with 3-point calibration accomplished at 50, 90, and 100% of span.

b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100% of span.

b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100% of span using a precision-resistance source.

b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100% open and closed.

9. Provide diagnostic and test instruments for calibration and adjustment of system.

10. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 1 Section "Project Closeout."

END OF SECTION 15900

SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:

a. Constant-volume air systems.

2. Hydronic Piping Systems:

a. Variable-flow systems.

3. HVAC equipment quantitative-performance settings.

4. Vibration measuring.

5. Sound level measuring.

6. Verifying that automatic control devices are functioning properly.

7. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

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

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

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

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

E. NC: Noise criteria.

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

G. RC: Room criteria.

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

I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

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

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

M. TAB: Testing, adjusting, and balancing.

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

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

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

1.4 SUBMITTALS

A. Qualification Data: Within 15 days from Contractor's Notice to Proceed, submit 2 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 15 days from Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 15 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC.

B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

D. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems

E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 PROJECT CONDITIONS

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

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

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

1.8 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."

D. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

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

F. Examine system and equipment test reports.

G. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

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

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

J. Examine plenum floors used for supply air to verify that they are airtight. Verify that wall penetrations and other holes are sealed.

K. Examine strainers for clean screens and proper perforations.

L. Examine three-way and by-pass valves for proper installation for their intended function of diverting or mixing fluid flows.

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

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

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

P. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.

2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.

4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.

5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.

6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.

8. Controller set points are set at indicated values.

9. Interlocked systems are operating.

10. Changeover from heating to cooling mode occurs according to indicated values.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

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

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

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

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

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

D. Verify that motor starters are equipped with properly sized thermal protection.

E. Check for airflow blockages.

F. Check condensate drains for proper connections and functioning.

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

H. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures and airflow at fan and at each outlet to determine actual static pressure and airflow.

B. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5%.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.

2. Check expansion tank liquid level.

3. Check makeup-water-station pressure gage for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.

6. Set system controls so automatic valves are wide open to heat exchangers.

7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 5% of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5% greater than indicated flow.

E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.

2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.

3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.9 PROCEDURES FOR MOTORS

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

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.10 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
3. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.
5. Capacity: Calculate in tons of cooling.
6. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.11 PROCEDURES FOR HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperature.

2. Water flow rate.

3. Water pressure drop.

4. Dry-bulb temperature of entering and leaving air.

5. Wet-bulb temperature of entering and leaving air for cooling coils.

6. Airflow.

7. Air pressure drop.

3.12 PROCEDURES FOR TEMPERATURE MEASUREMENTS

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

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

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

3.13 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.14 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10%.

2. Air Outlets and Inlets: 0 to minus 10%.

3. Cooling-Water Flow Rate: 0 to minus 5%.

3.15 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Pump curves.

2. Fan curves.

3. Manufacturers' test data.

4. Field test reports prepared by system and equipment installers.

5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.

2. Name and address of TAB firm.

3. Project name.

4. Project location.

5. Engineer's name and address.

6. Contractor's name and address.

7. Report date.

8. Signature of TAB firm who certifies the report.

9. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

10. Summary of contents including the following:

    a. Indicated versus final performance.

    b. Notable characteristics of systems.

    c. Description of system operation sequence if it varies from the Contract Documents.

11. Nomenclature sheets for each item of equipment.

12. Data for terminal units, including manufacturer, type size, and fittings.

13. Notes to explain why certain final data in the body of reports varies from indicated values.

14. Test conditions for fans and pump performance forms including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.

    b. Conditions of filters.

    c. Cooling coil, wet- and dry-bulb conditions.

    d. Fan drive settings including settings and percentage of maximum pitch diameter.

    e. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.

2. Water and steam flow rates.

3. Duct, outlet, and inlet sizes.

4. Pipe and valve sizes and locations.

5. Balancing stations.

6. Position of balancing devices.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.

b. Location.

c. Coil type.

d. Number of rows.

e. Fin spacing in fins per inch o.c.

f. Make and model number.

g. Face area in sq. ft.

h. Tube size in NPS.

i. Tube and fin materials.

j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Average face velocity in fpm.

c. Air pressure drop in inches wg.

d. Outside-air, wet- and dry-bulb temperatures in °F.

e. Return-air, wet- and dry-bulb temperatures in °F.

f. Entering-air, wet- and dry-bulb temperatures in °F.

g. Leaving-air, wet- and dry-bulb temperatures in °F.

h. Water flow rate in gpm.

i. Water pressure differential in feet of head or psig.

j. Entering-water temperature in °F.

k. Leaving-water temperature in °F.

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.

b. Location.

c. Make and type.

d. Model number and size.

e. Manufacturer's serial number.

f. Arrangement and class.

g. Sheave make, size in inches, and bore.

h. Sheave dimensions, center-to-center, and amount of adjustments in inches.

2. Motor Data:

a. Make and frame type and size.

b. Horsepower and rpm.

c. Volts, phase, and hertz.

d. Full-load amperage and service factor.

e. Sheave make, size in inches, and bore.

f. Sheave dimensions, center-to-center, and amount of adjustments in inches.

g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.

c. Fan rpm.

d. Discharge static pressure in inches wg.

e. Suction static pressure in inches wg.

H. Packaged Chiller Reports:

1. Unit Data:

   a. Unit identification.

   b. Make and model number.

   c. Manufacturer's serial number.

   d. Refrigerant type and capacity in gal.

   e. Starter type and size.

   f. Starter thermal protection size.

   g. Compressor make and model number.

   h. Compressor manufacturer's serial number.

2. Air-Cooled Condenser Test Data (Indicated and Actual Values):

   a. Refrigerant pressure in psig.

   b. Refrigerant temperature in °F.

   c. Entering- and leaving-air temperature in °F.

3. Evaporator Test Reports (Indicated and Actual Values):

   a. Refrigerant pressure in psig.

   b. Refrigerant temperature in °F.

   c. Entering-water temperature in °F.

   d. Leaving-water temperature in °F.

   e. Entering-water pressure in feet of head or psig.

   f. Water pressure differential in feet of head or psig.

4. Compressor Test Data (Indicated and Actual Values):

   a. Suction pressure in psig.

   b. Suction temperature in °F.

   c. Discharge pressure in psig.

   d. Discharge temperature in °F.

e. Oil pressure in psig.

f. Oil temperature in °F.

g. Voltage at each connection.

h. Amperage for each phase.

i. Kilowatt input.

j. Crankcase heater kilowatt.

k. Chilled-water control set point in °F.

l. Condenser-water control set point in °F.

m. Refrigerant low-pressure-cutoff set point in psig.

n. Refrigerant high-pressure-cutoff set point in psig.

5. Refrigerant Test Data (Indicated and Actual Values):

a. Oil level.

b. Refrigerant level.

c. Relief valve setting in psig.

d. Unloader set points in psig.

e. Percentage of cylinders unloaded.

f. Bearing temperatures in °F.

g. Vane position.

h. Low-temperature-cutoff set point in °F.

I. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.

b. Location.

c. Service.

d. Make and size.

e. Model and serial numbers.

f. Water flow rate in gpm.

g. Water pressure differential in feet of head or psig.

h. Required net positive suction head in feet of head or psig.

i. Pump rpm.

j. Impeller diameter in inches.

k. Motor make and frame size.

l. Motor horsepower and rpm.

m. Voltage at each connection.

n. Amperage for each phase.

o. Full-load amperage and service factor.

p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.

b. Pump shutoff pressure in feet of head or psig.

c. Actual impeller size in inches.

d. Full-open flow rate in gpm.

e. Full-open pressure in feet of head or psig.

f. Final discharge pressure in feet of head or psig.

g. Final suction pressure in feet of head or psig.

h. Final total pressure in feet of head or psig.

i. Final water flow rate in gpm.

j. Voltage at each connection.

k. Amperage for each phase.

J. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3.17 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

2. Randomly check the following for each system:

a. Measure airflow of air outlets.

b. Measure water flow of terminals.

c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.

d. Measure sound levels at two locations.

e. Verify that balancing devices are marked with final balance position.

f. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.

3. Owner shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10% of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10% of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.18 ADDITIONAL TESTS

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

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 16010

GENERAL PROVISIONS - ELECTRICAL WORK

PART 1 GENERAL

1.1 PRINCIPAL WORK IN THIS SECTION

A. This Section covers and applies to all work specified in Division 16.

B. Work Included in this Division: Materials, equipment, fabrication, installation and tests for fully operational and safe systems, including all necessary materials, appurtenances and features whether specified or shown on drawings or not, in conformity with applicable codes and authorities having jurisdiction for the following: Electrical work specified in all sections within Division 16 of these specifications and electrical drawings, including, but not limited to:

1. Electrical power distribution system.

2. Power for new chillers, pumps and fan coil units.

3. Electrical grounding system.

4. Cutting and patching for the Electrical Work.

5. Adjustment and testing of the Electrical Work.

6. Examine the drawings and specifications of other Divisions and provide electrical service for all equipment, devices and controls noted therein, unless work specifically is not included.

1.2 RELATED WORK AND REQUIREMENTS

A. Requirements of General Conditions and Division 1 applies to all work in this section.

B. Carefully check the documents of each Section with those of other Sections and Divisions. Ascertain the requirements of any interfacing materials or equipment being furnished and/or installed by those Sections and Divisions, and provide proper installation and/or required interface.

1.3 REFERENCE STANDARDS

A. Published codes, specifications standards, tests or recommended methods of trade, industry or governmental organizations, or local utilities apply to work in this Division where cited below:

1. ANSI - American National Standards Institute.

2. ASTM - American Society of Testing and Materials.

3. CBM - Certified Ballast Manufacturers.
4. CEC - California Electrical Code
5. AEIC - Association of Edison Illuminating Companies.
6. ETL - Electrical Testing Laboratories.
7. FCC - Federal Communications Commission.
8. ICEA - Insulated Cable Engineers Association.
9. IEEE - Institute of Electrical and Electronics Engineers.
10. IES - Illuminating Engineering Society.
11. NEC - National Electrical Code.
12. NEMA - National Electrical Manufacturer's Association.
13. NFPA - National Fire Protection Association.
14. OSHA - Occupational Safety and Health Act.
15. UBC - Uniform Building Code.
16. UL - Underwriters' Laboratories Inc.
17. State of California Codes.
18. State of California, Cal. OSHA.
19. State of California, California Administrative Code, Title 24.
20. County of Riverside Codes.
21. Local Building Department.
22. Local Fire Department.
23. NETA - National Electrical Testing Association Inc.

B. In addition to complying with all other legal requirements, comply with current provisions of governing Codes and Regulations in effect during the progress of the Work, and with the following:

1. Drawings and specification requirements shall govern where they exceed Code and Regulation requirements.

2. Where requirements between governing Codes and Regulations vary, the more restrictive provision shall apply.

3. Nothing contained in Contract Documents shall be construed as authority or permission to disregard or violate legal requirements. The contractor shall immediately draw the attention of the Owner's Representative to any such conflicts noted in the contract documents.

1.4 QUALITY ASSURANCE

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

B. Supply all equipment and accessories new, free from defects and listed by Underwriters' Laboratories, Inc. or bearing its label.

C. Supply all equipment and accessories in compliance with the applicable standards listed in article 1.03 of this section and with all applicable national, state and local codes.

D. All items of a given type shall be the products of the same manufacturer. Contractor shall provide same manufacturer's product throughout the project.

1.5 SUBMITTALS

A. Submit shop drawings, product data, samples and certificates of compliance required by contract documents. See Submittals paragraph in Division 1.

B. Submit no later than 30 days after signing of Contract:

1. Complete schedule of submittals for equipment and layout shop drawings.

2. Submittals schedule shall be in such sequence as to cause no delay in work or in work of any other division.

C. Corrections or comments made on the shop drawings during review do not relieve the Contractor from compliance with requirements of the drawings and specifications. Shop drawing checking by the Engineer is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The Contractor is responsible for:

1. Confirming and correlating all quantities and dimensions.

2. Selecting fabrication processes and techniques of construction.

3. Coordinating his work with all other trades.

4. Performing his work in a safe and satisfactory manner.

5. Provide equipment that can be installed in the available space with all code clearances. Prior to ordering any equipment.

D. Quantity of Submittals Required:

1. Layout Shop Drawings:

a. Submit one reproducible transparency and two prints.

b. Upon review, transparency will be annotated and returned. Print will be retained by Engineer.

c. Additional prints will not be reviewed nor returned.

2. Product data (brochures):

a. Submit six copies of product data.

b. Five copies will be returned.

c. If comments are required, comment sheet(s) will be returned with each copy.

d. One copy will be retained by the Engineer.

3. Samples:

a. Submit as directed by the Owner's Representative and as required in each specification section.

E. Submittal Format:

1. Number each submittal in consecutive order.

2. In each submittal include complete index with following information:

a. Project title and number.

b. Submittal number.

c. Referenced specification Division, Section, Title, paragraph and page number or drawing reference as applicable and flap each applicable item.

d. Date of submission.

e. Referenced addendum or change order number as applicable.

f. Names of Contractor, supplier and manufacturer.

g. Description of item.

h. Stamp with Contractor's initials or signed certifying:

1) Review of submittal.

2) Verification of products, field measurements and field construction criteria.

3) Coordination of shop drawing and/or information in submittal with requirements of work of this Division and other divisions of Contract Documents.

3. Nomenclature, legend, symbols and abbreviations on submitted material shall be same as used in contract documents.

F. Resubmission Requirements:

1. Make any corrections or change in submittals required. Resubmit only items required for resubmittal for review until no exceptions are taken or a resubmission is not required.

2. Shop Drawings and Product Data:

a. Revise initial drawings or data, and resubmit as specified for initial submittal.

b. Indicate any changes which have been made other than those requested.

c. Provide written response of all previous comments with the resubmittals.

3. Samples: Submit new samples as required for initial submittal.

4. Clearly identify resubmittal by original submittal date, number and revision number and indicate all changes from previous submittal.

G. Substitutions:

1. In the event of conflict, the provisions of this paragraph shall override those contained in Submittals and Substitutions paragraphs in Division 1.

2. As a general, substitutions are not acceptable except for hereafter condition:

a. Requests for substitutions shall be considered only in case of product unavailability. Product unavailability shall be verified in writing by manufacturer.

b. Submit separate request for each substitution at appropriate time thereafter in the event of non-availability of item included in bid. Support each request with:

1) Complete data substantiating compliance of proposed substitution with requirements stated in Contract documents.

2) Data relating to changes in construction schedule.

3) Any effect of substitution on other Work in this and other Divisions, and any other related contracts, and changes required in other work or products.

c. Contractor shall be responsible at no extra cost to Owner for any changes resulting from proposed substitutions which affect work of other Sections or Divisions, or related contracts.

d. Substitute products shall not be ordered or installed without prior acceptance by Owner's Representative.

e. Owner's Representative will have sole discretion to determine acceptability of proposed substitutions and reserves the right to reject any such substitution.

f. Approval of substitutions shall not relieve Contractor from full compliance with requirements of Contract documents.

H. Layout Shop Drawings Required:

1. Prepare and submit following coordinated layout shop drawings on 1/4-inch scale:

a. UPS Room with equipment dimensions and all associated feeder conduit routing.

b. Areas requiring deviations from design documents. Such deviations shall be clearly identified.

2. Layout drawings not varying from design documents shall not be submitted and will not be reviewed.

I. Operating Instructions, Maintenance Manuals and Parts Lists.

1. Before requesting acceptance of work submit one set for review by Owner's Representative.

2. After review, furnish five printed and bound sets.

3. Include:

a. Manufacturer's name, model number, service manual, spare-parts list, and descriptive literature for all components, cross referenced and numbered on Reference Drawings.

b. Maintenance instructions.

c. Listing of possible breakdown and repairs.

d. Instruction for starting, operation and programming.

e. Detailed and simplified one line and wiring diagrams.

f. Field test report.

g. Name, address and phone number of contractors, equipment suppliers and service agencies.

h. Assemble manufacturer's equipment manuals in chronological order following the specification alpha-numeric system in heavy duty three-ring binders clearly titled on the spine and front cover.

J. Record Drawings:

1. Comply with requirements from Division 1.

2. Submit to Owner's Representative for review prior to final acceptance inspection, one complete marked-up set of reproducible drawings.

3. Submit to Owner's Representative for review prior to final acceptance inspection, one complete set of reproducible engineering design drawings on electronic files using ACAD and one vellum set.

a. Fully illustrate all revisions made by all trades.

b. Include all field changes, adjustments, variances, substitutions and deletions, including all changes made by Change Orders.

c. Exact location, type and function of all equipment.

4. These drawings shall be for record purposes for Owner's use and are not considered Shop Drawings.

1.6 DESCRIPTION OF BID DOCUMENTS

A. Specifications:

1. Specifications, in general, describe quality and character of materials and equipment.

2. Specifications are of simplified form and include incomplete sentences.

3. Words or phrases such as "The Contractor shall," "shall be," "furnish," provide," "a," "an," "the," and "all" etc. have been omitted for brevity.

B. Drawings:

1. Electrical layouts are generally diagrammatic and, although size and location of equipment is drawn to scale wherever possible, Contractor shall make use of all data in Contract Documents and verify this information at building site.

2. Locations of items on the drawings may be distorted for purposes of clearness and legibility. Actual locations of Owner's Representative and mechanical items are shown on Owner's Representative and mechanical drawings.

3. Outlets shall be located in accordance with Owner's Representative design, and specific locations may be determined by Owner's representative at jobsite prior to installation.

4. Outlets located on Owner's Representative plans by dimension shall be held. Additional outlets may be shown on electrical plans and shall be installed as close as practical to the location shown.

5. Manufacturers' drawings and instructions shall be followed in all cases where the makers of devices and equipment furnish directions, where details are not shown on the drawings, or where described in the specifications.

6. Work installed in a manner contrary to that shown in the contract documents shall be removed and reinstalled when so directed by the Owner. Discrepancies and questionable points shall be immediately reported to the Owner's Representative for clarification.

C. If any part of specifications or drawings appears unclear or contradictory, apply to Owner's Representative for his interpretation and decision as early as possible, including during bidding period. Do not proceed with such work without Owner's Representative's decision.

1.7 DEFINITIONS

A. "Furnish" or "Provide": To supply, install and connect complete and ready for safe and regular operation of particular work referred to unless specifically otherwise noted.

B. "Install": To erect, mount and connect complete with related accessories.

C. "Supply": To purchase, procure, acquire and deliver complete with related accessories.

D. "Work": Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

E. "Wiring": Raceway, fittings, wire, boxes and related items.

F. "Concealed": Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosures.

G. "Exposed": Not installed underground or "concealed" as defined above.

H. "Indicated" "Shown" or "Noted": As indicated, shown or noted on drawings or specifications.

I. "Equal": Equal in quality, workmanship, materials, weight, size, design and efficiency of specified product, conforming with "Manufacturers".

J. "Reviewed," "Satisfactory," "Accepted," or "Directed": As reviewed, satisfactory, accepted or directed by or to Owner's Representative.

K. "Motor Controllers": Manual or magnetic starters (with or without switches), individual

pushbuttons, or hand-off-automatic (HOA) switches controlling the operation of motors.

L. "Control Devices": Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

1.8 ELECTRICAL SYSTEM CHARACTERISTICS

A. Electric distribution: 480V 3Ø 3w with grounded neutral and 208/120v 3Ø4w with grounded neutral.

B. High intensity discharge and fluorescent lighting: 120 volts, unless otherwise noted.

C. Motors 1/2 HP and above: 480 volts, 3 phase, unless specifically indicated otherwise.

D. Fractional horsepower motors less than 1/2 HP: 120 volts or 208V single phase.

E. Incandescent lighting and general receptacles will be supplied at 120 volt.

1.9 COORDINATION STUDY

A. Contractor shall submit a computerization short circuit and coordination study, prepared for electrical overcurrent devices to be installed under this project to assure proper equipment and personnel protection. Organized time-current analysis of each protective device in series from the individual device back to the source. The study shall reflect the operation of each device during normal and abnormal current conditions. The study devices for the following:

1. UPS System

2. Distribution panels.

B. Submittals: Submit the study for review as specified above for submittal procedures:

1. Shop drawings: Submit protective equipment Shop Drawings simultaneous with or after the protective device study. Protective equipment Shop Drawings will not be reviewed without protective device coordination study.

2. Certification: Two weeks prior to the final inspection, deliver four (4) copies of certification by the Contractor that the protective devices have been adjusted and set in accordance with the final protective device study.

C. Qualifications: Prepare coordination study by qualified engineers of the switchboard manufacturer or qualified agency.

D. Study Requirements: Include a system one line diagram, short circuit, and protective coordination plots.

1. One line diagram:

a. Show all electrical equipment and wiring to be protected by the overcurrent devices installed under this Project. Show schematic wiring of the electrical

distribution system.

b. Submit following specific information on time one line diagram:

1) Calculated fault impedance, X/R ratios, and short circuit value at each bus.

2) Breaker and fuse ratings.

3) Transformer KVA and voltage ratings, percent impedance, X/R ratios, and wiring connections.

c. Voltage at each bus.

d. Identification of each bus.

e. Conduit material, feeder sizes, length, and X/R ratios.

2. Short circuit study (including ground fault system):

a. Systematically calculate the fault impedance to determine the available short circuit currents at each bus.

b. Calculate by means of a digital computer. Incorporate pertinent data and the rationale employed in developing the calculations in the introductory remarks of the study.

c. Present the data determined by the short circuit study in a table format. The following shall be included:

1) Device identification.

2) Operating voltage.

3) Protective device.

4) Device rating.

5) Calculated short circuit current.

3. Coordination curves: Prepare the coordination curves to determine the required settings of protective devices to assure selective coordination. The curves shall graphically illustrate on log-log paper that adequate time separation exists between series devices. The specific time-current characteristics of each protective device shall be plotted in such a manner that all upstream devices will be clearly depicted on one sheet.

4. Provide the following specific information on the coordination curves:

a. Device identification.

b. Voltage and current ratio for curves.

c. 3-phase and 1 phase ANSI damage points for each transformer.

d. No-damage, melting, and clearing curves for fuses.

e. Transformer inrush points.

f. Maximum short circuit cut-off points.

5. Develop a table to summarize the settings selected for the protective devices. Included in the table shall be the following:

a. Device identification.

b. Tap, time dial, and instantaneous pickup.

c. Circuit breaker sensor rating, long-time, and time bands.

d. Fuse rating and type.

e. Rating of all current limiting fuses where current limiting fuses have been installed to protect downstream circuit breakers.

6. Adjustments, settings, and modifications:

a. Accomplish necessary field settings, adjustments, and minor modifications for conformance with the study, without additional cost to the Owner (examples of minor modifications would be trip size within the same frame, the time curve characteristics of relays, C.T. ranges, etc.).

b. Proposed major corrective modifications will be reviewed by the Owner's Representative and the Contractor will be given further instructions.

1.10 JOB CONDITIONS

A. Examine all drawings and specifications in a manner to be fully cognizant of all work required under this Division.

B. Adjoining work of other Divisions shall be examined for interferences and conditions affecting this Division.

C. Examine site related work and surfaces before starting work of any Section.

1. Report to Owner's Representative, in writing, conditions which will prevent proper provision of this work.

2. Beginning work of any Section without reporting unsuitable conditions to Owner's Representative constitutes acceptance of conditions by Contractor.

3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

1.11 MOUNTING HEIGHTS

A. Mounting heights of devices and equipment shown on the Owner's Architectural drawings shall govern, but in the absence of such indications, the following centerline heights above the finished floor shall be maintained.

1. Wall switches - 3 feet - 6 inches in accordance with Title 24 and ADA (or as directed by Owner's Representative).

2. Wall lights (interior) - 7 feet - 0 inches in accordance with Title 24 and ADA (or as directed by Owner's Representative).

3. Convenience receptacles - 1 foot - 3 inches in accordance with Title 24 and ADA except in Toilets and over cabinets or -counters where devices shall be mounted at 4 feet - 0 inches (9 inches above counter).

4. Fire alarm stations - 4 feet - 0 inches in accordance with Title 24 and ADA.

5. Telephone and communication outlets - 1 foot - 3 inches in accordance with Title 24 and ADA.

6. Panelboard cabinets - Shall be installed with the top 6 feet - 6 inches above the floor for cabinets more than 2 feet - 6 inches high and 6 feet - 0 inches for cabinets less than 2 feet - 6 inches high.

1.12 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Check dimensions of access route through the site from delivery point to final location. Where necessary, ship in crated sections of size to permit passing through available space. Dismantle and/or reassemble, reprovision and retest equipment too large to pass through available access route to final location in one piece.

B. Ship equipment in original packages, to prevent damaging or entrance of foreign matter.

C. Handle and ship in accordance with manufacturer's recommendations.

D. Provide and maintain protective coverings during construction.

E. Replace at no expense to Owner, equipment or material damaged during storage or handling, as directed by Owner's Representative.

F. Tag all items with weatherproof tag, identifying equipment by name and purchase order number.

G. Include packing and shipping lists.

H. Special requirements as specified in individual sections.

1.13 SEISMIC RESTRAINTS

A. Provide seismic restraints per applicable code. Design and provide restraints to prevent permanent displacement in any direction caused by lateral motion, overturning or uplift. Submit calculations and details to Architect for approval.

B. General: Provide Zone 4 seismic restraints per applicable code and as specified and/or indicated. Design and provide restraints to prevent permanent displacement in any direction caused by lateral motion, overturning or uplift. Requirements:

1. Occupancy category:

2. Major equipment including:

a. UPS, Battery Cabinet, By Pass Cabinet, Static Transfer Switch, PDU.

b. Floor mounted distribution panels.

3. Other equipment and apparatus:

a. Panelboards.

b. Starters, including those furnished under other sections.

c. Life safety related enclosures and devices.

C. Equipment: If required to be restrained, the equipment itself must be designed to withstand the required seismic force criteria, including its internal design, components and frame; and must have suitable structural elements to which restraining attachments may be fastened.

D. Rigidly supported equipment: Restrain per SMACNA, NUSIG guidelines where applicable; where not applicable restrain similarly and as recommended by manufacturer of equipment.

E. Design:

1. Prepare designs, including arrangements, sizes and model numbers indicated or referenced in applicable standards.

2. Where designs, etc., are neither indicated nor referenced, prepare such designs as required by Owner's Representative, together with supporting calculations prepared by a duly licensed engineer registered in the State of California.

1.14 PROTECTION OF MATERIALS

A. Protect from damage, water, dust, etc., material, equipment and apparatus provided under this Division, both in storage and installed, until Notice of Completion has been filed.

B. Provide temporary storage facilities for material and equipment.

C. Arrange with Owner's Representative for storage facilities for materials and equipment.

D. Material, equipment or apparatus damaged because of improper storage or protection will be rejected. Remove from site and provide new, duplicate, material equipment or apparatus in replacement of that rejected.

E. Protect premises and work of other Divisions from damage arising out of installation of work of this Division.

1. Repair or replace, as directed by Owner's Representative, materials and parts of premises which become damaged as result of installation of work of this Division.

2. Remove replaced parts from premises.

1.15 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by representatives of Owner.

B. Advise Owner's Representative that work is ready for review at following times:

1. Prior to concealment of work below computer room raised floor, in walls and above ceilings.

2. When all requirements of Contract have been completed.

C. Maintain on site a set of Specifications and Drawings for use by Owner's representatives.

1.16 SCHEDULE OF WORK

A. Arrange work to conform to schedule and phasing of construction established or required to comply with Contract Documents.

B. In scheduling, anticipate means of installing equipment through available openings in structure.

C. Arrange schedule for work in each area.

D. Unless otherwise directed perform work during normal working hours.

1.17 PERMITS, LICENSES, AND INSPECTIONS

A. Permits and Licenses: Secure required permits and licenses including payments of all charges and fees.

B. Inspections:

1. Obtain certificates of final inspection approval from authorities having jurisdiction, and submit to Owner's Representative before acceptance of the Work.

2. Obtain inspections during the Work as required to allow timely progress of these and other trades.

1.18 GUARANTEE

A. Guarantee all materials, equipment, apparatus and workmanship to be free of defective materials and faulty workmanship for period of one year from date of filing of Notice of Completion. Unless extended guarantee periods are specified in individual sections.

B. This guarantee also applies to services such as Instructions, Adjusting, Testing, Noise, etc...

C. Equipment manufacturers shall include extended warranty to give full coverage during warranty period, unless longer period is specified.

1.19 PRELIMINARY OPERATION

A. Any portion of the system or equipment shall be placed in operation at the request of the Owner prior to the final completion and acceptance of the work. Such operation shall be under the direct supervision of the Contractor, but the expense thereof will be paid separately and distinct from any money paid on account of the Contract.

B. Preliminary operation or payment thereof shall not be construed as acceptance of any part of the Work.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. When specific names are not stated, only the best available quality of material or equipment shall be submitted for review and used in the installation.

B. Named materials shall comply with the specifications. Where the phrase "equal to" or words of similar intent are used in reference to material or equipment, the product is specified as to type and construction only and equivalent products may be submitted for review.

C. Where names of selected manufacturers and certain types of material are shown or specified without the use of the above phraseology, the Contractor shall base his proposal and work on use of the selected products and only such products shall be submitted for review.

2.2 MATERIALS AND EQUIPMENT

A. Access Tile Identification: Buttons, tabs and markers: To identify location of concealed work. Submit to Owner's Representative for review.

B. Nameplates:

1. Screwed on engraved white laminated plastic sheet with minimum 3/8 inch to 3/4 inch black lettering. For normal system and red laminated plastic with white lettering for emergency system.

2. Inscription: Subject to review, indicating equipment and voltage.

3. Provide nameplates for the following:

   a. Disconnect switches.

   b. Individually mounted circuit breakers.

   c. Panels.

   d. Device plate.

C. Inserts and Supports:

1. Inserts:

   a. Under General Construction Work.

   b. Provide additional acceptable means of support attachments as required, after review.

   c. Provide cutting and patching required to install additional attachments.

2. Supports from building construction: Inserts, beam clamps, fishplates, cantilever brackets or other means. Submit for review.

3. Grouped lines and services: Trapeze hangers of bolted angles or channels.

4. Where building construction is inadequate: Provide additional framing. Submit for review.

PART 3 EXECUTION

3.1 INSTALLATION

A. Layout and installation of electrical work shall be coordinated with the overall construction schedule and work schedules of various trades, to prevent delay in completion of the Project.

1. Complete drawings and specifications for the entire project will be available at the Project site.

2. It shall be obligatory to thoroughly check these drawings before organizing the electrical work schedule, or installing material and equipment.

B. Dimensions and information regarding accurate locations of equipment, and structural limitations and finish shall be coordinated and verified with other Division of Work. Be prepared to promptly furnish dimensions and information regarding electrical Work to other trades and cooperate with them to secure harmony and the best progress of the Project.

C. The drawings do not show off-sets, bends, and special fittings, or junction or pull boxes

necessary to meet job conditions. These items shall be provided as required at no additional cost to the Owner.

D. Accessibility and Clearance:

1. Electrical equipment, outlets, junction and pull boxes shall be installed in accessible locations, avoiding obstructions, preserving headroom, and keeping openings and passageways clear.

2. Minor adjustments in the locations of equipment shall be made where necessary, providing such adjustments do not adversely affect functioning of the equipment.

E. Scaffolds and staging for installation of electrical work shall be provided under the work of this Division.

F. Occupied Building: The building will remain occupied and operational during construction. All work will be closely coordinated with Owner's representative to avoid any disruption to day to operation of various system for the building.

G. The cutover of existing UPS Panels to new UPS system will be closely coordinated with the RCIT and PSEC group so there is minimum planned interruption to the data operating system.

3.2 STRUCTURAL FITTINGS

A. Furnish and install the necessary sleeves, inserts, hangers, anchor bolts, and related structural items. Install at the proper time.

B. Sleeves shall be supplied for electrical conduits passing through walls or slabs and shall be placed before concrete is poured.

C. Equipment supports for electrical work shall be fastened to the structure by inserts, anchor bolts, bolting to drilled and tapped structural members.

1. Surfaces damaged by installation of supports shall be touched up with primer to match shop coat. Any drilling of structural members shall be approved by the Owner's Representative.

D. Flashing:

1. Wherever conduits pass through the roof or outer walls, base flashing and counterflashing shall be provided.

2. Such flashing shall be properly installed by skilled workmen, and shall include grouting, mastic or tar application, or other means to insure a permanent, waterproof, neat and workmanlike installation.

3. Insofar as possible, flashing shall comply with and be similar to requirements for flashing in General Construction Work.

E. Anchor bolts and inserts shall be galvanized and of adequate size and strength for installation of electrical work.

1. Placement of anchor bolts (KB-3Z) bolts in existing concrete slab for seismic bases (under raised floor) for UPS, Battery Cabinet, By Pass Cabinet, Static Transfer Switch, PDU shall be coordinated with Owner's representatives.

F. Cutting and patching:

1. All additional cutting, patching and reinforcement of construction of building, subject to review by the Owner's Representative, shall be performed under this Section.

3.3 COOPERATION WITH OTHERS

A. The work has been shown in locations suited to accommodate the work of others. Interferences between the work of various trades shall be promptly reported to the Owner's Representative for adjustment and clarification.

B. Electrical work installed in a manner that interferes with the work of another trade shall be removed and reinstalled at no additional cost to the Owner's Representative.

3.4 NOISE AND VIBRATION

A. Exceeding specified limits or due to faulty equipment or workmanship: Correct as directed without additional charge.

3.5 PAINTING

A. Paint:

1. Best grade for its purpose.

2. Deliver in original sealed containers.

3. Apply in accordance with manufacturer's instructions.

4. Colors: As selected.

B. Galvanized iron primer: Panel and pull boxes, after fabrication.

C. Hot dipped galvanized or dipped in zinc chromate: Outlet boxes, junction boxes, conduit hangers, rods inserts and supports.

D. Zinc chromate with finish to match surroundings: Marred surfaces of steel equipment and raceways.

E. Field applied zinc chromate prime coat: Steel or iron work.

3.6 CLEANING

A. Brush and clean work prior to concealing, painting and acceptance. Perform in stages if directed.

B. Painted exposed work soiled or damaged: Clean and repair to match adjoining work before final acceptance.

C. Remove dust and debris from inside and outside of material and equipment.

3.7 IDENTIFICATION OF CIRCUITS AND EQUIPMENT

A. Tags shall be attached to feeder wiring in conduits at every point where runs are broken or terminated. Tag also pull wires in empty conduits.

1. Circuit, phase, and function shall be indicated. Tags may be made of pressure sensitive plastic or embossed self-attached stainless steel, brass ribbon or engraved laminated plastic.

2. Branch circuit wiring shall be tagged with numbered adhesive strip.

B. Cardholders and cards shall be provided for circuit identification in panelboards. Cardholders shall consist of a metal frame permanently attached to the inside of panel door, with clear plastic cover for directory card.

1. List of circuits shall be typewritten on card. Circuit description shall include name or number of circuit, area, and connected load.

2. Provide new directories for panels where circuits have been revised, added or deleted.

C. Junction and Pull boxes shall have covers stenciled with box number when shown on the drawings, or circuit numbers according to panel schedules. Data shall be lettered in a conspicuous manner with a color contrasting to finish.

D. Receptacle and switch plates shall be suitably labeled with panel and circuit number it is fed from.

3.8 CONNECTIONS TO EQUIPMENT

A. Connections to equipment furnished under other Divisions or by Owner shall be part of the electrical work.

1. Work shall include wiring for equipment without factory fabricated wiring; connection to motors when the motor is supplied as a separate unit; and connections only for equipment furnished with factory installed internal wiring, except as further limited by the drawings and other portions of the specifications.

2. Work shall include furnishing suitable outlets, disconnecting devices, starters, control devices, pushbutton stations, selector switches, conduit, junction boxes, wire and wiring devices necessary for complete electrical installation.

3. Devices and equipment furnished shall be of the same type used elsewhere on the project or as specified herein. Location and electrical requirements of such equipment shall be verified in advance with the Contractor or manufacturer furnishing the equipment.

B. Equipment specified under other Divisions for installation and/or connection under Work of this Division will be delivered to the installation location by the Contractor furnishing the equipment.

C. Equipment furnished under other Divisions, and requiring electrical connection under this Division will be set in place by Contractor furnishing the equipment.

D. Suitability and connection of equipment specified under other Divisions shall be determined in advance of installation. Immediate notice shall be given to the affected parties of damage, unsuitability, or lack of parts. No connection shall be made until satisfactory resolution of the deficiencies has been accomplished.

3.9 ADJUSTMENTS AND TESTS

A. The entire electrical installation shall be tested by a qualified testing laboratory, adjustments made, and defects corrected. Contractor shall submit proof of the qualification of testing agency.

B. Wiring shall be tested for continuity, short circuits, and improper grounds. Insulation resistances shall comply with values stated in the applicable Electrical Code.

C. Devices and equipment shall be checked for correct functional performance in accordance with apparatus ratings, operating sequence and Code requirements.

D. All motors shall be checked and adjusted for correct direction of rotation.

E. Loading of circuits and feeders in panelboards shall be checked and balanced.

F. Repair or replace defective work or equipment, at no cost to Owner.

G. For additional testing see other sections.

END OF SECTION

SECTION 16110

RACEWAYS

PART 1 GENERAL

1.1 PRINCIPAL WORK IN THIS SECTION

A. Provide raceways complete with boxes, fittings and accessories.

B. Minimum 3/4-inch conduit except 3/8-inch between recessed lighting fixture and outlet box.

1.2 QUALITY ASSURANCE

A. Refer to the General Provisions – Electrical Work.

1.3 GUARANTEES

A. Refer to the General Provisions – Electrical Work.

PART 2 PRODUCTS

2.1 RACEWAYS

A. All conduits shall be metallic unless otherwise indicated or noted. Metallic conduit incorporated in the work shall comply with applicable divisions of the National and American Standards Association publications.

1. Rigid steel conduit: Full weight pipe, galvanized, threaded.

2. Electro-metallic tubing (EMT): Thin wall pipe, galvanized, threadless.

3. Flexible metallic conduit: Continuous single strip, aluminum or galvanized steel.

4. Wireways: Complete with all fittings and accessories. Size as noted, baked enamel finish inside and outside, approved for support at minimum 10 feet on centers.

a. Interior use: Hinged cover and base, minimum thickness 16 gauge galvanized steel.

b. Exterior use: Hinged cover and base, minimum No. 14 gauge galvanized steel, weatherproof and gasketed.

5. Surface metal raceways: Complete with all fittings and accessories. Size as noted, extruded aluminum.

a. Snap-on covers.

b. Isoduct Series Wiremold Co.

2.2 FITTINGS AND ACCESSORIES

A. Raceway Fittings:

1. Rigid steel and intermediate metal conduits: Non-split, threaded, steel or malleable iron with steel locknuts. Zinc die cast not permitted.

2. Electro-metallic tubing: Compression type. Entering enclosures, boxes, etc. insulated throat type with locknuts.

3. Flexible metallic conduit: Setscrew type with insulated throat.

4. Bushings: Metallic insulated type.

5. Weatherproof or dust tight installations (under raised floor): Liquid-tight with sealing ring and insulated throat.

B. Seals:

1. Raceways in waterproof sleeves: O.Z. Type WSK thru wall seal.

2. Raceways in non-watertight sleeves: Sealing compound.

3. Thruwall cable seals: O.Z. Type WSCS.

C. Expansion Fittings:

1. Exposed and in furred spaces: Flexible conduit with external bonding jumper strip.

2. In slab: O.Z. Type AX, AX-8, or Appleton type XJ with ground continuity.

D. Cables in raceways through sleeves: O.Z. type KSC compound or type C series terminators.

E. Fire Sealants - UL listed: Chase Foam, CTC PR-855, 3M Product or approved equal fire resistant foam sealant.

2.3 BOXES

A. Outlet boxes, except as otherwise required by construction, devices or wiring, as follows:

1. Stamped or welded steel, 4 inch square or octagon for:

a. Lighting fixtures: 1-1/2 inch deep above ceiling, 3 inch deep in slab, 2-1/8 inch deep in wall.

b. In wall for receptacles and switches: 1-1/2 inch deep.

c. In wall for telephone and data: 2-1/8 inch deep

d. With raised covers and fixture studs where required.

e. Through-the-wall type, not permitted.

f. Without fixture or device: Blank cover.

g. Offset back-to-back outlets: Minimum 6-inch separation.

2. Galvanized cast iron or aluminum with threaded hubs: 4 inch round, 2 inch deep on ceiling, and 4 inch square, 2 inch deep on wall.

3. Boxes without fixture or device: Provide with blank cover.

B. Junction and Pull Boxes:

1. Galvanized sheet steel: Code size and gauge in accordance with voltage parameters.

2. Covers: Screw-on, above ceiling full access.

3. With insulated supports for cables.

4. Locations: Shall be accessible as indicated and where required by code.

5. Outdoors and damp locations: Galvanized cast iron or aluminum with threaded hubs and gaskets.

6. Provide barriers or separate boxes between wiring energized from different systems; 120/208, 277/480 volt wiring, and emergency and normal wiring.

C. Unused openings in boxes, conduit bodies, and fittings shall be blanked off by means of approved metal plugs or plates.

PART 3 EXECUTION

3.1 INSTALLATION

A. Procedure:

1. Raceways shall be installed as complete (total) wiring enclosure system prior to installation of conductors.

2. All conduit joints shall be cut square, threaded, reamed smooth and drawn up tight. Bends or offsets shall be made with standard conduit elbows, field bends made with an approved bender or hickey.

3. Paint male threads of field threaded conduit with homogenized blend of colloidal copper and rust and corrosion inhibitor pipe compound, Thomas and Betts Kopr-Shield or approved equal. Butt conduit ends.

4. Conduits shall be secured to all boxes, cabinets, panels, and equipment with locknuts and bushings in such manner that each system shall be electrically continuous throughout.

5. Conduits shall be securely fastened in place on maximum 10-foot intervals; hangers, supports, or fastenings shall be provided at each elbow and at end of each straight run terminating at a box or cabinet.

6. Provide pull boxes as indicated and/or where required by Code and where necessary in the raceway system to facilitate conductor installation. Conduit runs of more than 100 feet, or with more than three right-angle bends, shall have a pull box installed at a convenient intermediate accessible location. Support boxes independently of raceways, walls and partitions. Boxes shall have removable hinged and/or screw covers and shall be accessible.

7. All conduits shall be terminated with bushings. Conduits at distribution panels will be terminated with grounding type bushing.

8. All metallic conduits 200 feet or larger shall have an equipment ground conductor and increase size, if required.

9. Protect empty conduit ends from entering debris during construction using push-penny plugs by Thomas and Betts or equally approved fittings and materials.

B. Raceways shall be run concealed, except in electrical, mechanical and similar area.

C. Supports and fastening shall be as follows:

1. Ceiling trapeze, strap hangers, or wall brackets.

2. U-bolt or pipe straps at each grating level of riser raceways.

3. Raceways shall be secured to support with pipe straps or U-bolts on Channel or Trapeze.

4. Spacing shall be maximum 10 foot on center for metallic conduit and wireways.

5. Supports shall be mounted to structure with:

a. Toggle bolts on hollow masonry.

b. Expansion shields or inserts on concrete and brick.

c. Machine screws on metal.

6. All supports shall be independent and shall not use ceiling supporting system wires.

7. Perforated straps, wire or hangers with clips are not acceptable.

D. Exposed raceways and raceways above suspended ceilings shall be run parallel with or at right angles to walls.

E. Clearance from water, steam or other piping: Minimum six inches separation from hot water pipes, except one inch from pipe cover at crossings.

F. Run raceways in walls vertically.

G. Maintain grounding continuity of interrupted metallic raceways with ground conductor, and in flexible conduit for feeders and motor terminal connections.

H. Empty raceways over 10 feet long: Provide with fish or pull wire, galvanized steel or nylon rope.

I. Fire Sealants:

1. Fire rated approved type sealant equivalent to the rating of the barrier being penetrated.

2. Provide for raceways and wire passing through slots, sleeves or openings in fire-partitioned areas. Add fire barriers tight to conductors from Transformer Vault.

3. Seal all unused penetrations.

J. Rigid Steel Conduits

1. As required.

K. EMT: Install for interior. Not permitted in concrete slabs.

L. Flexible Steel Conduit (with equipment grounding conductor):

1. For short connections (maximum six feet length) of branch circuits only where installation of rigid or EMT conduit is impractical and connection is in a dry location, dry wall, hung ceiling or furred spaces.

2. From outlet box to recessed lighting fixture: Minimum four feet, maximum six feet length.

3. For final connection to motor terminal box, transformers and other vibrating equipment: With polyvinyl sheathing and grounding conductor. Minimum length: 18 inches with minimum 50% slack. Connect grounding conductor to enclosure or raceway at each end.

4. For expansion joint crossings, cross at right angles and anchor ends.

M. Outlet Boxes:

1. Set square and true with building finish and secure to building structure by adjustable strap irons.

2. Verify outlet locations in finished spaces with Drawings of interior details and finishes.

3. Provide barriers between switches connected to different phases for voltages exceeding 150 volts to ground.

4. Protect floor boxes from entering debris during construction using removable screw covers.

N. Panel, Junction and Pull Boxes:

1. Location: Clear of other work. Conceal junction and pull boxes in finished spaces and maintain accessibility.

2. Support from building structure, independent of conduit. Provide floor to ceiling channels for mounting on dry wall and lightweight construction.

3. Junction boxes for fixtures recessed in hung ceiling: accessible through opening created by removal of fixture. Secure to black iron ceiling support.

4. Motor terminal boxes: Coordinate with motor branch circuit conduit and wiring.

5. Paint Life Safety system conduit (2 inch band every 5 feet) outlet, pull and junction boxes red (both inside and outside before they are installed).

3.2 TESTS

A. Continuity:

1. Test resistance of feeder conduits from service to point of final distribution using one (1) conductor return.

2. Maximum: 25 ohms resistance.

END OF SECTION