

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

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

1.3 DEFINITIONS

- A. EER: Energy-efficiency ratio.
- B. IPLV: Integrated part-load value.

1.4 SUBMITTALS

- A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Complete set of manufacturer's certified 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: Power, signal, and control wiring.
- C. Certificates: For certification required in "Quality Assurance" Article.
- D. Source quality-control test reports.
- E. Startup service reports.

- F. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
- G. Warranties: Special warranties specified in this Section.

#### 1.5 QUALITY ASSURANCE

- A. ARI Certification: Signed by manufacturer certifying compliance with requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
- B. ASHRAE Certification: Signed by manufacturer certifying compliance with ASHRAE 15 for safety code for mechanical refrigeration. Comply with ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.
- C. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. Comply with NFPA 70.
- E. Comply with UL 1995.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship water chillers from the factory fully charged with refrigerant or nitrogen.

#### 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.

#### 1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship.

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Scroll Water Chillers:
    - a. Carrier; a United Technologies Company.
    - b. Trane Company (The).

- c. YORK International Corporation.

## 2.2 PACKAGED WATER CHILLERS

- A. Description: Factory-assembled and -tested water chiller complete with compressor(s), evaporator, condenser, controls, interconnecting unit piping and wiring, indicated accessories, and mounting frame.
1. Casing: Weatherproof, constructed of hot-dip galvanized steel with factory-painted finish.
  2. Acoustical sound blanket.
  3. Acoustical compressor enclosure.
  4. Fans: Propeller type, statically and dynamically balanced, with vertical air discharge for high efficiency and low sound; located in its own compartment to eliminate cross flow of condenser air during fan cycling; and equipped with heavy-gage, weather-protected fan guard.
  5. Fan Motor: Direct drive, weatherproof, with bearings permanently lubricated, and having built-in current- and thermal-overload protection.
- B. Water Chiller Characteristics and Capacities: As scheduled on drawings.

## 2.3 SCROLL COMPRESSORS

- A. Description: Positive displacement, direct drive with suction and discharge service valves, crankcase oil heater, current and temperature sensitive motor overload protection, and suction strainer. The compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
- B. Capacity Control: Hot-gas bypass.
- C. Refrigerant and Oil: HCFC-22.
- D. Refrigerant Compatibility: Seals, O-rings, motor windings, and internal water chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
- E. Refrigerant Circuit: Two independent circuits. Each circuit shall include a thermal expansion valve, refrigerant charging connections, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

## 2.4 HEAT EXCHANGERS

- A. Evaporator:
1. Description: Stainless steel brazed plate.

2. Water side working pressure shall be 350 psig and the refrigerant side working pressure shall be 300 psig.

B. Condenser:

- C. Air-Cooled Condenser: Copper tubes with mechanically bonded aluminum fins, integral subcooling circuit, leak tested at 420 psig.

1. Safety and Operating Options: Controls for low-ambient operation down to 0°F.

2.5 INSULATION

- A. Cold Surfaces: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type II, for sheet materials.

1. Thickness: 3/4 inch.
2. Adhesive: As recommended by insulation manufacturer.
3. Factory apply insulation over entire surfaces of water chiller components.
  - a. Apply adhesive to 100 percent of insulation contact surface.
  - b. Seal seams and joints.
  - c. After adhesive has fully cured, apply two coats of protective coating to insulation.

2.6 ACCESSORIES

- A. Factory-installed hot-gas bypass.
- B. Low-ambient head pressure.
- C. Chilled-water flow switch.
- D. Suction and discharge pressure gages.
- E. Condenser coil guard.

2.7 CONTROLS

- A. Control Panel: Stand-alone, microprocessor based control system furnished by chiller manufacturer.
- B. Enclosure: Unit-mounted, NEMA 250, Type 3R enclosure, hinged or lockable; factory wired with a single-point power connection and a separate control circuit.
- C. Status Display: Multiple-character liquid-crystal display or light-emitting diodes and keypad. Display the following conditions:
  1. Date and time.
  2. Operating or alarm status.
  3. Operating hours.

4. Outside-air temperature if required for chilled-water reset.
  5. Temperature and pressure of operating set points.
  6. Entering and leaving temperatures of chilled water.
  7. Entering and leaving temperatures of condenser water (for water-cooled water chillers only).
  8. Refrigerant pressures in evaporator and condenser.
  9. Saturation temperature in evaporator and condenser.
  10. No cooling load condition.
  11. Elapsed time meter (compressor run status).
  12. Water pump status (optional).
  13. Antirecycling timer status.
  14. Percent of maximum motor amperage.
  15. Current-limit set point.
  16. Number of compressor starts.
- D. Control Functions:
1. Manual or automatic startup and shutdown time schedule.
  2. Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water temperature shall be reset based on return-water temperature.
  3. Current limit and demand limit.
  4. Condenser-water temperature (for water-cooled water chillers only).
  5. External water chiller emergency stop.
  6. Antirecycling timer.
  7. Automatic lead-lag switching.
- E. Manually Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
1. Low evaporator pressure or high condenser pressure.
  2. Low chilled-water temperature.
  3. Refrigerant high pressure.
  4. High or low oil pressure.
  5. High oil temperature.
  6. Loss of chilled-water flow.
  7. Loss of condenser-water flow (for water-cooled water chillers only)
  8. Control device failure.
  9. Compressor motor current-overload.
  10. Starter fault.
- F. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control chilled-water set point and chiller-control displays and alarms.
1. The following point shall be monitored by the BMS:
    - a. System water supply and return temperature.
    - b. Ambient refrigerant temperature.
    - c. System chilled water flow.
    - d. System chiller enable/disable.
    - e. System pump on/off.
    - f. Chilled water setpoint.

- g. System demand setpoint.

## 2.8 MOTORS

- A. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment."
  - 1. Open-drive motors shall have flanged or flexible coupling suitable for direct connection to compressor.

## 2.9 MAGNETIC ENCLOSED CONTROLLERS

- A. Enclosure: Unit mounted, NEMA 250, Type 3R, with hinged access door with lock and key or padlock and key.
- B. Control Circuit: 120 V; obtained from integral control power transformer with a control power source of enough capacity to operate connected pilot and indicating and control devices.
- C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of water chiller control microprocessor.
- D. Star-Delta Controller: NEMA ICS 2, closed transition.
- E. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
  - 1. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  - 2. Light-emitting-diode indicators showing motor and control status, including the following conditions:
    - a. Controller on.
    - b. Overload trip.
    - c. Loss of phase.
    - d. Starter fault.
- F. Accessories: Devices shall be factory installed in controller enclosure, unless otherwise indicated.
  - 1. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hard-wired connections.

## 2.10 SOURCE QUALITY CONTROL

- A. Factory test and rate water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Water Compression Cycle." Stamp with ARI label.
- B. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

- C. Rate sound power level according to ARI 575 procedure.
- D. Rate sound power level according to ARI 370 procedure.
- E. Allow Owner access to places where water chillers are being source quality-control tested. Notify Architect 14 days in advance of testing.

### **PART 3 - EXECUTION**

#### 3.1 EXAMINATION

- A. Before water chiller installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
  - 1. Final 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. Install water chillers on concrete base. Concrete base is specified in Division 15, Section 15050 "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.
- B. Concrete Bases: Anchor chiller mounting frame to concrete base.
  - 1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 3. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 4. Cast-in-place concrete materials and placement requirements are specified in Division 3.
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Charge water chiller with refrigerant if not factory charged.
- E. Install separate devices furnished by manufacturer.

#### 3.3 CONNECTIONS

- A. Chilled water piping installation requirements are specified 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 Connections: Connect inlet to evaporator with controller-bulb well, shutoff valve, thermometer, strainer, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, flow switch, balancing valve, thermometer, pressure gage, and union or flange.
- D. Ground water chillers according to Division 16 Section "Grounding and Bonding."
- E. Connect wiring according to Division 16 Section "Conductors and Cables."
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.4 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 according to manufacturer's written instructions.
  - 5. Check bearing lubrication and oil levels.
  - 6. Verify that refrigerant pressure relief is vented outside (for water-cooled water chillers).
  - 7. Verify proper motor rotation.
  - 8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
  - 9. Verify and record performance of chilled water flow and low-temperature interlocks.
  - 10. Verify and record performance of water chiller protection devices.
  - 11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Prepare a written startup report that records results of tests and inspections.
- E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

### 3.5 DEMONSTRATION

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

**END OF SECTION 15628**



SECTION 15726

MODULAR OUTDOOR AIR-HANDLING UNITS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes constant-volume and variable air volume, modular air-handling units with coils for outdoor installations.
- B. Related Sections include the following:
  - 1. Division 15 Section "Humidifiers" for steam grid humidifiers not an integral part of modular outdoor air-handling units specified in this Section.

1.3 SUBMITTALS

- A. Product Data: For each type of modular outdoor air-handling unit indicated. Include the following:
  - 1. Certified fan-performance curves with system operating conditions indicated.
  - 2. Certified fan-sound power ratings.
  - 3. Certified coil-performance ratings with system operating conditions indicated.
  - 4. Motor ratings, electrical characteristics, and motor and fan accessories.
  - 5. Material gages and finishes.
  - 6. Filters with performance characteristics.
  - 7. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
  - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field Quality-Control Test Reports: From manufacturer.

1.4 REFERENCES

- A. ARI 430 - Standard for Central Station Air Handling Units.
- B. ARI 410 - Standard for Forced Circulation Air-Cooling and Air-Heating Coils.
- C. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- D. UL 1995 - Heating and Cooling Equipment
- E. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- F. SMACNA - HVAC Duct Construction Standards.
- G. ANSI/UL 900 - Test Performance of Air Filter Units.
- H. AMCA 300 - Reverberant Method for Sound Testing of Fans.
- I. ARI 260 - Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment
- J. AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices.
- K. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain modular outdoor air-handling units through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of modular outdoor air-handling units 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. NFPA Compliance: Modular outdoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
- E. ARI Certification: Modular outdoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- F. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."
- B. Coordinate size and location of structural-steel support members.

1.7 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. Filters: Two sets for each modular outdoor air-handling unit.
  - 2. Fan Belts: One set for each modular outdoor air-handling unit fan.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Carrier; Div. of United Technologies Corp.
  - 2. Trane Company (The); Worldwide Applied Systems Group.
  - 3. York International Corporation.

2.2 MANUFACTURED UNITS

- A. Modular outdoor air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, damper, plenums, filters, condensate pans, mixing dampers, control devices, and accessories.

2.3 CABINET

- A. Materials: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
  - 1. Outside Casing: Galvanized steel, 0.063 inch thick.
  - 2. Inside Casing: Galvanized steel, 0.0276 inch thick, perforated where indicated.
  - 3. Floor Plate: Galvanized steel, 0.1382 inch thick.
- B. Cabinet Insulation: Comply with NFPA 90A or NFPA 90B.
  - 1. Materials: ASTM C 1071 with coated surface exposed to air stream to prevent erosion of glass fibers.
  - 2. Thickness: 2 inches.

3. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature. Minimum R-value of 10.0.
  4. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C 411.
  5. Location and Application: Factory applied with adhesive and mechanical fasteners between the sheet metal panels. Factory applied injected foam is also a suitable alternative.
- C. Access Panels and Doors: Same materials and finishes as cabinet, complete with hinges, latches, handles, and gaskets. Access panels and doors shall be easily operable without the use of tools. Inspection and access panels and doors shall be sized and located to allow periodic maintenance and inspections. Access doors shall be constructed with a double-wall of solid G90 galvanized steel interior panel. Gasketing around the full perimeter of the access door shall be used to prevent air and water leakage. Provide access panels and doors in the following locations:
1. Fan Section: Doors.
  2. Access Section: Doors.
  3. Coil Section: Doors.
  4. Damper Section: Doors.
  5. Filter Section: Doors to allow periodic removal and installation of filters.
- D. Condensate Drain Pans: Formed sections of stainless-steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) and humidifiers when units are operating at maximum catalogued face velocity across cooling coil.
1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
  2. Drain Connections: Both ends of pan.
  3. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.
- E. Exterior Paint Finish: External surface of unit casing shall be prepared and factory coated with a minimum 1.5 mil enamel finish or equal. Unit casing exterior with factory coating shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours. Unit casing will be provided with manufacturer's standard color.
- F. Sloped Roof Construction: Unit roof shall be sloped a minimum 0.25 inch per foot either from one side of unit to other or from center to sides of the unit. Roof assembly shall overhang all walls of units by 2 inches minimum.
- G. Outside Air Intake Hoods: For units with outside air requirements, manufacturer shall provide inlet hood with high performance sine wave moisture eliminator to prevent water carryover into unit casing from outside air. Hoods shall be sized for 100% economizer cycle. If eliminator is not factory provided, contractor shall be responsible for field supplying and installing in manufacturers standard outside air inlet hood (s). If louvers are provided, then louvers shall be tested by an Independent AMCA approved laboratory for water carryover and air pressure drop in accordance with AMCA Standard 500, and testing reports shall be supplied with the submittal data.

2.4 FAN SECTION

- A. Fan-Section Construction: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan with restrained vibration isolation.
- B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.
  - 1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  - 2. Performance Class: AMCA 99-2408, Class I, II or III as scheduled or required by the design operating conditions.
  - 3. Horizontal Flanged Split Housing: Bolted construction.
  - 4. Plug Fans: With steel cabinet. Fabricate without fan scroll and volute housing.
- C. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower. Variable frequency drive controlled blowers shall be dynamically balanced throughout the entire blower speed range.
- D. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange, heavy back plate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.
- E. Coatings: Powder-baked enamel.
- F. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed for constant speed blowers or throughout the fan operating range for a variable speed blower at the rated motor horsepower, with final alignment and belt adjustment made after installation. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM.
  - 1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
  - 2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
  - 3. Key fan wheels to fan shaft to prevent slipping and to permit removal of the fan wheel.
- G. Pre-lubricated and Sealed Shaft Bearings: Provide self-aligning, grease lubricated pillow-block ball bearings selected for L-50 200,000 hour average life per ANSI/AFBMA 9. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.
- H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.2 service factor based on fan motor.
  - 1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

2. Motor Pulleys: Adjustable pitch for constant speed blowers; fixed pitch for use with motors controlled by variable frequency drives. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  3. Belts: Oil resistant, non-sparking, and non-static; matched for multiple belt drives.
- I. Motor Mount: Adjustable for belt tensioning.
  - J. Vibration Control: Install fans on open-spring vibration isolators having a minimum of 1-inch static deflection and side snubbers suitable for seismic zone 4 requirements.
  - K. Fan-Section Source Quality Control:
    1. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
    2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."
  - L. Grating: Provide minimum 6"x6" welded wire grating at the floor of the unit suitable to prevent maintenance/installation workers from falling into the duct connections.
  - M. The Piezometer ring airflow measurement system shall consist of multiple probes with velocity measuring sensors. Sensors shall be annular configuration mounted in the fan inlet bell by the fan mfg. The sensors shall include a piezometer ring mounted in the throat of the fan inlet bell(s) and an annular static pressure probe mounted on the face of the inlet cone.
  - N. The fan airflow measuring device shall not restrict airflow through the fan inlet cone or cause a system effect on the fan.

## 2.5 MOTORS

- A. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment."
- B. Noise Rating: Quiet.
- C. Motors controlled by variable frequency drives shall be rated for inverter duty service.

## 2.6 COILS

- A. Coil Sections: Common or individual, insulated, galvanized-steel casings for heating and cooling coils. Design and construct to facilitate removal and replacement of coil for maintenance and to ensure full airflow through coils.
- B. Water Coils: Self-draining coil fabricated according to ARI 410.
  1. Piping Connections: Threaded, on same end.

2. Tubes: Copper.
3. Fins: Aluminum, with spacing to match the scheduled performance.
4. Fin and Tube Joint: Mechanical bond.
5. Headers: Seamless copper tube with brazed joints, prime coated.
6. Frames: Galvanized-steel channel frame.
7. Source Quality Control: Test to 300 psig and to 200 psig underwater.

## 2.7 DAMPERS

- A. Damper Operators: Electric as specified in Division 15 Section "HVAC Instrumentation and Controls."
- B. Low-Leakage, Outside-Air Dampers: Double-skin, airfoil-blade aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed blade for modulating applications or parallel-blade for two position applications with aluminum or steel operating rods rotating in sintered bronze or nylon bearings mounted in a single aluminum frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.
- C. Mixing Boxes: Opposed-blade galvanized-steel dampers mechanically fastened to steel operating rod in reinforced, galvanized-steel cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
- D. Airflow Monitoring Station: Provide a factory-mounted damper/airflow monitoring station in the outdoor air damper opening of the mixing box as scheduled on the drawings. Damper blades shall be galvanized steel, housed in a galvanized steel frame and mechanically fastened to an axle rod rotating on bearings. The dampers shall be rated for a maximum leakage rate of less than 1 percent of nominal cfm at 1 in. wg. The airflow measurement station shall measure up to 100 percent of airflow. The airflow monitoring station shall output a 2-10 VDC signal representing velocity and shall have a total accuracy of +/-5 percent of actual flow down to 15 percent of nominal flow between -40 F and +158 F.

## 2.8 FILTER SECTION

- A. Filters: Comply with NFPA 90A.
- B. Filter Section: Provide filter holding frames arranged for flat or angular orientation as scheduled, with access doors on both sides of unit. Filters shall be removable from either side of unit.
- C. Extended-Surface, Disposable Panel Filters: Factory-fabricated, dry, extended-surface filters with holding frames.
  1. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting grid.
  2. Media and Media-Grid Frame: Nonflammable cardboard.
  3. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks. Frames shall be reusable.

2.9 EXTERNAL PIPING CABINETS

- A. Piping enclosure shall be supplied by the manufacturer factory assembled and shall be of the same construction as the main unit casing. Piping cabinet shall be external to the unit and be shipped separate for field installation in order to facilitate piping of the unit coil(s) and humidifier dispersion tube condensate drain(s). Piping cabinet to cover unit sections as specified on schedule and shall have access door, or removable panels, as specified. The external piping cabinet shall be insulated with a minimum of 2" thick fiberglass blanket insulation.

2.10 ROOF CURB

- A. Galvanized steel roof mounting curb with wood nailing strip, and neoprene gasket shall be supplied by the unit manufacturer. If unit requires external piping cabinet, a separate curb shall be supplied for support of the external cabinet and shall be connected to the unit curb. The roof curb shall be provided with continuous insulation and shall be a standard height of 24" unless indicated otherwise. Roof curb shall be used as a plenum and have a divider to separate supply and return air flow.

2.11 FACTORY INSTALLED VARIABLE FREQUENCY DRIVE(S)

- A. Combination Variable Frequency Drive / line break switches shall be properly sized, mounted, wired to the fan motor, and commissioned by the AHU manufacturer. Combination VFD / line break switches shall include the VFD, a circuit breaker disconnect, a Drive-Off (H-O-A) switch, manual speed control dial, and a control transformer. Variable frequency shall have the capability of communicating with the facility BAS system.
- B. Variable Frequency Drive(s): The VFD shall be a high performance pulse width modulated (PWM) AC drive that generates a sine-code, variable voltage/frequency, three phase output for optimum speed control. The inverter section shall utilize only intelligent power modules (IPM's) to generate an 8kHz PWM output to ensure a low audible magnetic motor noise (@ 60 Hz) of less than 2 dB (@ 1 meter) above across the line operation. Power electronics shall provide at least 96% efficiency. The VFD shall be digitally based using a common microprocessor control logic circuit board for the horsepower ratings. Programming shall be maintained in non-volatile RAM memory so the program will be maintained when power is removed. A digital operator keypad and display shall provide local control and readout for: run/stop, speed, reset, volts, amps, kilowatts, and diagnostics. Output current overload should be rated at 110% of motor FLA for one minute. The VFD shall have the following minimal protective features: current limited stall prevention, auto restart after momentary power loss, speed search for starting into rotating motor, anti-windmill w/DC injection before start, phase-to-phase short circuit protection, and ground fault protection. Ambient service temperature rating of -10 to 50 degrees C, and humidity rating to 95% non-condensing. The VFD shall be supplied with a bypass to allow across the line operation of the connected equipment in the event of drive failure. The VFD shall be UL508C listed and CSA certified and shall conform to applicable NEMA, ICS, NFPA, IEC, and ISO 9001 standards. VFD's shall also comply with the requirements of Division 16.
- C. Factory Mounting: VFD/Disconnect shall be factory-mounted on the drive side of the air handling unit fan section.



- D. Factory Wiring: VFD / disconnects shall be wired to fan motor per required NEC, UL, NFPA 90, and Division 16 requirements.
- E. Factory Commissioning: Trained factory personnel shall ensure proper operation of the VFD by a thorough factory test. Testing shall include "Hypot" test of unit wiring to insure that no weaknesses exist in VFD, wiring, or motor. VFD should be energized and fan run at 22Hz, 40Hz, and 60Hz to insure VFD will operate throughout usable range of drive and that the fan rotation is correct. The fan will be tested in bypass position to insure that the bypass is operational. VFD shall have auto restart after a power failure.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install modular outdoor air-handling units with vibration control devices.
  - 1. Curb-Mounted Units: Support on continuous rail insulated curb designed to meet the unit loading requirements. Install continuous neoprene gasketing between unit base and the curb for air and weather tight seal. Secure units to the curb. Seal between the unit base and the plenum curb divider to prevent short circuiting of supply air flow and return air flow.
  - 2. Piping Chase Curbs: External pipe chases shall be sealed air and weather tight to the chase curb and to the roof top unit casing.
- B. Arrange installation of units to provide access space around modular outdoor air-handling units for service and maintenance.

#### 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. Connect piping to externally isolated modular outdoor air-handling units with flexible connectors.

- D. Connect condensate drain pans using NPS 1-1/4, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping." Connect to supply and return coil tapings with shutoff or balancing valve and union or flange at each connection.
- F. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.
- G. Electrical: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.
- H. Ground equipment according to Division 16 Section "Grounding and Bonding."
- I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
  - 1. Leak Test: After installation, fill water and steam coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
  - 2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

#### 3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Final Checks before Startup: Perform the following:
  - 1. Verify that shipping, blocking, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
  5. Lubricate bearings, pulleys, and other moving parts with factory-recommended lubricants.
  6. Set outside- and return-air mixing dampers to minimum outside-air setting.
  7. Comb coil fins for parallel airflow orientation.
  8. Install clean filters.
- C. Starting procedures for modular outdoor air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
  2. Measure and record motor electrical values for voltage and amperage.
  3. Manually operate dampers from fully closed to fully open position and record fan performance.
- D. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for modular outdoor air-handling system testing, adjusting, and balancing.

### 3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

### 3.7 CLEANING

- A. Clean modular outdoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
- B. After completing system installation and testing, adjusting, and balancing modular outdoor air-handling and air-distribution systems, clean filter housings and install new filters.

### 3.8 PAINT TOUCH-UP

- A. Touch up damage to the external paint system with factory matched color paint.

### 3.9 DEMONSTRATION

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

**END OF SECTION 15725**



SECTION 15734

COMPUTER-ROOM AIR-CONDITIONING UNITS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following types of computer-room air-conditioning units:
  - 1. Ceiling-mounting units.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For computer-room air-conditioning units to include in emergency, operation, and maintenance manuals.
- E. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

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

- B. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- C. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

1.5 COORDINATION

- A. Coordinate layout and installation of computer-room air-conditioning units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air-conditioning units that fail in materials or workmanship within specified warranty period.
- B. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
- C. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.7 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. Fan Belts: One set for each belt-drive fan.
  - 2. Filters: One set of filters for each unit.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ceiling-Mounting Units
    - a. Carrier Corp.
    - b. Data Aire Inc.
    - c. Liebert Corporation.
    - d. Stulz Investment Corp. of America.

## 2.2 CEILING-MOUNTING UNITS

- A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls.
- B. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch thick duct liner.
- C. Evaporator Fan: Forward curved, centrifugal, and directly driven by two-speed motor.
  - 1. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment."
    - a. Noise Rating: Quiet.
- D. Chilled-Water Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve. Mount coil assembly over stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
- E. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switch.
- F. Filter: 4-inch thick, pleated type.
- G. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
  - 1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap on drain.
  - 2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
  - 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- H. Control System: Unit-mounted panel with main fan contactor, control transformer with circuit breaker, solid-state temperature and humidity control modules, humidifier contactor, time-delay relay, reheat contactor, and high-temperature thermostat. Provide for interface with BAS system for remote start-stop, adjustable humidity set point, and adjustable temperature set point.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install computer-room air-conditioning units level and plumb, maintaining manufacturer's recommended clearances.
- B. Install suspended components level. Secure units as shown on the structural drawings.

- C. Support suspended units from structure using threaded steel rods and elastomeric hangers according to manufacturers recommendations. Vibration-control devices and installation requirements are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

### 3.2 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: Comply with applicable requirements in Division 15 Section "Domestic Water Piping." Provide adequate connections for condensate drain and humidifier flushing system.
- D. Electrical System Connections: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.
- E. Ground equipment according to Division 16 Section "Grounding and Bonding."
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 2. After installing computer-room air-conditioning 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.

### 3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that computer-room air-conditioning units are installed and connected according to manufacturer's written instructions and the Contract Documents.



- C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 16 Sections.
- D. Complete installation and startup checks according to manufacturer's written instructions.
- E. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.6 DEMONSTRATION

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

**END OF SECTION 15734**



SECTION 15740

HEAT EXCHANGERS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes plate heat exchangers for HVAC applications.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product indicated. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- B. Maintenance Data: For heat exchangers to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."
- B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Plate Heat Exchangers:
    - a. Alfa Laval Thermal, Inc.
    - b. Armstrong Fluid Handling; Div. of Armstrong International, Inc.
    - c. FlatPlate, Inc.
    - d. ITT Fluid Handling; Div. of ITT Fluid Technology Corp.
    - e. Mueller: Paul Mueller Co.
    - f. Polaris
    - g. Taco, Inc.
    - h. Tranter, Inc.; Texas Div.
    - i. Triangle Tube/Phase III Co., Inc.

2.2 PLATE HEAT EXCHANGERS

- A. Basis of Design: Polaris PHE.
- B. Configuration: Brazed assembly consisting of two end plates, one with nozzles, and pattern-embossed plates.
- C. End-Plate Material: ASTM A 666, Type 316 stainless steel.
- D. Plate Material: ASTM A 666, Type 316 stainless-steel shell.
- E. Piping Connections: Threaded.

**PART 3 - EXECUTION**

3.1 EXAMINATION

- A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HEAT EXCHANGER INSTALLATION

- A. Install heat exchangers according to manufacturer's written instructions.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.
- C. Install piping with threaded or flanged connections at heat exchangers.
- D. Install shutoff valves at heat exchanger inlet and outlet connections.
- E. Install relief valves on heat exchanger heated-fluid connection.

3.4 CLEANING

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

3.5 COMMISSIONING

- A. Verify that heat exchangers are installed and connected according to the Contract Documents.
- B. Adjust flows and controls to deliver specified performance.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers as specified below:
  - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining heat exchangers.
  - 2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
  - 3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  - 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

**END OF SECTION 15740**



SECTION 15752

GAS-FIRED HUMIDIFIERS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following type of humidifiers:
  - 1. Self-contained humidifiers for application on ducted HVAC systems.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities, operating weights, furnished specialties, and accessories.
- B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, and dispersion tubes.
  - 1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
  - 2. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, and required clearances.
- C. Maintenance Data: For humidifiers to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with ARI 640, "Standard for Commercial and Industrial Humidifiers."

1.5 COORDINATION

- A. Coordinate location and installation of humidifiers in air-handling units. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Self-Contained Gas-Fired Humidifiers:
    - a. Armstrong International, Inc.
    - b. Dri-Steem Humidifier Co.
    - c. Herrmidifier Co., Inc.
    - d. Nortec Industries, Inc.

2.2 SELF-CONTAINED GAS-FIRED HUMIDIFIERS

- A. Basis of Design: Dri-Steem GTS-200
- B. Description: Gas-fired with stainless steel heat exchanger and stainless steel tank to generate steam. Enclosure cabinet contains equipment components.
  - 1. Remotely mounted dispersion with flexible hose connecting dispersion tube in air handler access module.
- C. Heat Exchanger and Burner: Humidifier and burner assembly shall be CSA/AGA/CGA certified and tested to support natural gas. Burner construction shall be stainless steel with welded joints. Burner shall modulate for turndown ratio of 4:1.
- D. Gas Train: Gas train assembly shall be complete with burner/mixing tube assembly, igniter, sight glass, flame rod electrode, gas manifold, integral gas valve, and venture.
- E. Dispersion Tube: Unit mounting, manifold-grid tube extending across entire width of air handler; connected to heat-exchanger housing with flexible hose and equipped with mounting brackets for both ends of tube.
- F. Cabinet: Sheet metal enclosure for housing heater cylinder, electrical wiring, components, controls, and control panel. Enclosure shall include baked-enamel finish in manufacturer's standard colors, hinged or removable access door, and threaded outlet in bottom of cabinet for drain piping. Enclosure shall have 1" of foil-faced fiberglass insulation. All surfaces except front panel shall be insulated.
- G. Control Panel: Factory-wired disconnect switch; liquid-crystal display, programmable keyboard; set-point adjustment; warning signal indicating end of replaceable cylinder life; low-



- voltage control circuit; diagnostic, maintenance, alarm, and status features; and high-water sensor or float to prevent overfilling.
- H. Controls: Solenoid-fill and automatic drain valves shall maintain water level and temper hot drain water; field-adjustable timer shall control drain cycle for flush duration and interval.
1. Water-Level Controller: Conductivity probe.
  2. Drain valve: Electric drain valve shall be included to automatic tank drain at the end of the humidification season
- I. Optional Accessories: Include the following:
1. Humidistat: Solid-state, electronic-sensor controller capable of full modulation.
  2. Duct-mounted, high-limit humidistat.
  3. Network capability.
  4. Airflow switch to prevent humidifier operation when there is no airflow.
  5. Provide water tempering device for discharge to sanitary.
  6. Provide weather protection devices for operation down to -40°F.
  7. 12 gauge, galvanized steel, 14" roof curb.

### **PART 3 - EXECUTION**

#### 3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 HUMIDIFIER INSTALLATION

- A. Install with required clearance for service and maintenance.
- B. Seal humidifier dispersion-tube duct penetrations with flange.
- C. Install dispersion tubes pitched to drain condensate back to housing.
- D. Install drip leg upstream from steam trap, a minimum of 12 inches for proper operation of trap.

#### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
  1. Install piping adjacent to machine to allow service and maintenance.

2. Install shutoff valve and strainer in humidifier supply line.
  3. Install backflow prevention device in humidifier supply line.
  4. Connect piping with a minimum of 1-inch air gap in fill line to prevent backflow into supply line.
  5. Install and connect gas piping per manufacturers instructions and NFPA 54 guidelines.
- B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.
- C. Ground equipment.
1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
  3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

### 3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.
1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
  2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
  3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

**END OF SECTION 15752**

SECTION 15766

CABINET UNIT HEATERS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes cabinet unit heaters.

1.3 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each unit type and configuration:
  - 1. Plans, elevations, sections, and details.
  - 2. Details of anchorages and attachments to structure and to supported equipment.
  - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
  - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.
- D. Field Test Reports: Written reports of tests specified in Part 3 of this Section.
- E. Maintenance Data: For cabinet unit heaters to include in maintenance manuals specified in Division 1. Include the following:
  - 1. Maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

1.4 QUALITY ASSURANCE

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

1.5 COORDINATION

- A. Coordinate layout and installation of cabinet unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.6 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Cabinet Unit Heater Filters: Furnish one set of spare filters for each filter size installed.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Carrier Corp.
  - 2. Trane Company (The); North American Commercial Group.
  - 3. Sterling.

2.2 CABINET UNIT HEATERS

- A. Description: An assembly including filter, chassis, coil, fan, and motor in blow-through configuration with heating coil.
- B. Cabinet: For one or more of the following configurations:
  - 1. Recessed, wall-mounting front grilles for air inlet and outlet.
  - 2. Recessed, ceiling-mounting front grilles for air inlet and outlet.
  - 3. Concealed with supply and return flanges for duct connection.

2.3 MATERIALS

- A. Chassis: Galvanized steel, with flanged edges **and unit-leveling bolts**.

- B. Coil Section Insulation: 1-inch duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
  - 1. Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.
- C. Cabinet: Galvanized steel, with removable panels fastened with tamperproof fasteners.
- D. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer with manufacturer's standard paint, in color selected by Architect, applied to factory-assembled and -tested cabinet unit heater before shipping.

#### 2.4 COILS

- A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and with manual air vent. Coils shall be rated for a minimum working pressure of 300 psig and a maximum entering water temperature of 275 deg F, with manual air vent.

#### 2.5 FAN

- A. Centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel or thermoplastic material; directly connected to motor.

#### 2.6 FAN MOTORS

- A. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment."
- B. Multispeed motor with integral thermal-overload protection and resilient mounts. Connect motor to chassis wiring with plug connection.

#### 2.7 ACCESSORIES

- A. Aluminum wall boxes with integral eliminators and insect screen.
- B. Steel subbase, height as indicated.
- C. Plastic motor-oiler tubes extending to beneath top discharge grille.
- D. Steel recessing flanges for recessing cabinet unit heaters into ceiling or wall.
- E. Filters: 1-inch thick, glass-fiber media in fiberboard frame.
- F. Dampers: Steel damper blade(s) with polyurethane stop across entire blade length and having factory-mounted electric operators for proportioning amounts of outside air and return air.

2.8 CONTROLS

- A. Control Devices: Unit-mounted fan-speed switch and wall-mounting thermostat.

2.9 SOURCE QUALITY CONTROL

- A. Test cabinet unit heater coils according to ASHRAE 33.

**PART 3 - EXECUTION**

3.1 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before cabinet unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cabinet unit heaters level and plumb.
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Suspend cabinet unit heaters from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
- D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Ground equipment.
- E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
  - 1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - 3. Test and adjust controls and safeties.
- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean cabinet unit heaters internally according to manufacturer's written instructions.
- C. Install new filters in each cabinet unit heater within two weeks after Substantial Completion.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.
  - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
  - 2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
  - 3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  - 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

**END OF SECTION 15766**





SECTION 15774

RADIANT FLOOR HEATING AND SNOWMELT SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following:
  - 1. Radiant floor heating products.
  - 2. Snowmelt system heating products.
  - 3. Floor heating controls.
- B. Related Sections include the following:
  - 1. Section 03300 - Cast-In-Place Concrete
  - 2. Section 15075 - Mechanical Identification
  - 3. Section 15083 - Piping Insulation
  - 4. Section 15181 - Hydronic Piping and Specialties
  - 5. Section 15185 - Hydronic Pumps
  - 6. Section 15900 - HVAC Instrumentation and Controls
  - 7. Section 01410 - Testing, Adjusting and Balancing of HVAC and Plumbing Systems

1.3 WORK INCLUDED

- A. Description: Furnish and install radiant floor heating (RFH) system piping, distribution manifold(s) with balancing and flow control valves, pipe to manifold compression nut fittings, manufacturer-approved cold-expansion compression-sleeve pipe repair couplings, non-metallic pipe fasteners, controls and installation specialties, supervision and field engineering required for complete and proper function of the radiant floor heating system and the snowmelt system.

1.4 REFERENCES

- A. ASTM F876 - Standard specification for cross-linked polyethylene (PEX) tubing
- B. CSA B137.5 - Cross-linked polyethylene (PEX) tubing systems for pressure applications.
- C. German standard DIN 4726 for plastic piping used in warm water floor heating systems.

1.5 SUBMITTALS

- A. Provide submittals and shop drawings in accordance with the General Requirements and as specified herein. Submit shop drawings indicating the layout of snowmelt system, Snowmelt/radiant floor heating equipment, critical dimensions and piping/slab penetration details as well as details for protecting exposed PEX piping.
- B. Submit each control component and related element. Provide a detailed schematic showing control components and a detailed wiring diagram for the field installation.
- C. Submit manufacturer's technical installation instructions.
- D. Submit independent certification results for the piping systems from a recognized testing laboratory.
- E. Submit catalog data on equipment, fittings, fasteners and associated items necessary for the installation of the piping and manifolds.
- F. Provide a manufacturer's warrantee certificate.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver and store piping and equipment in shipping containers with labeling in place. Pipe to be maintained in the original shipping boxes until required for installation. Do not expose pipe to ultraviolet (sun) light for more than 30 days.
- B. Protect piping and manifolds from entry of contaminating materials by installing suitable plugs in open pipe ends until final installation. Connect pipes to assembled manifolds to eliminate possibility of contaminants.
- C. Piping shall not be dragged across the ground or concrete surfaces, and shall be stored on a flat surface with no sharp edges.
- D. Pipe shall be protected from oil, grease, paint and other elements as recommended by the manufacturer.

1.7 WARRANTY

- A. The radiant floor heating tubing manufacturer shall warrant the cross-linked polyethylene tubing to be free from defects in material and workmanship for a period of twenty-five (25) years. The design shall be approved by submittal as being complete and accurate.

- B. See Section 15000 and Division 1 for additional warranty requirements.

#### 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum of five years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc. as suitable for the purpose specified and indicated.

#### 1.9 SNOWMELT DESIGN CRITERIA

- A. Outside Design Conditions: 10 deg. F /10 MPH wind.
- B. Fluid Temperature Drop: 25 degrees F.
- C. Snowmelt Design Surface Temperature: 38 deg. F.
- D. Slab Heat Output/Load: 107 BTU/SF.
- E. Tubing Spacing: 9" on center.
- F. Total Area of Snowmelt: 1520 SF.
- G. Tubing Size: 5/8" nominal inside diameter (3/4" OD)
- H. Tubing length (approximate): 2402 LF.
- I. Heat Transfer Fluid: 50% propylene glycol/50% water.
- J. Loop Flow: 1.6 GPM
- K. Loop Head Loss: 9.3 ft TDH.

### PART 2 - PRODUCTS

#### 2.1 TUBING

- A. Cross-linked polyethylene (PEXa) pipe shall be manufactured by the peroxide (Engel) method, and conform to ASTM F876 and CSA B137.5. Fittings shall conform to ASTM F877 and CSA B137.5.
- B. Temperature and Pressure Ratings: Piping shall be rated for 100 PSIG gauge pressure at 180 degrees F temperature (690 kPa @ 82°C) continuous, and 80 PSIG gauge pressure at 200 degrees F temperature (550 kPa @ 93°C) continuous.

- C. Oxygen Diffusion Barrier: Piping shall have a co-extruded oxygen diffusion barrier capable of limiting oxygen diffusion through the pipe to less than 0.10 mg/l/day at 104 degrees F (40°C) water temperature, in accordance with DIN 4726.
- D. Bend Radius: The minimum bend radius for cold bending of the pipe shall be not less than five (5) times the outside diameter. Bends with a radius less than this shall require the use of a bending template as supplied by the pipe manufacturer, and heating the tubing.
- E. Radiant Floor Design Criteria: The tubing shall be 1/2" nominal inside diameter (5/8" OD), with maximum loop lengths of 375 feet depending on the floor covering. Use manufacturers recommendations to determine maximum loop lengths for each floor covering type. Loop pressure drop shall not exceed 10 ft, TDH. Loop temperature drop shall not exceed 20 degrees F.
- F. Temperature Limits
  - 1. The floor heating system controller shall limit the supply water temperature to the design temperature listed on the drawing schedule or 120 degrees F if no temperature is indicated.
  - 2. The floor slab temperature is limited to 88 degrees F.

## 2.2 FITTINGS

- A. Fittings shall be manufactured of dezincification-resistant brass and shall be supplied by the piping manufacturer as part of a proven cataloged system. Manifold fittings to be compression nut style with split compression ring.
- B. Fittings shall be certified to ASTM F877 and CSA B137.5 as part of the manufacturer's PEX piping system. Pipe couplings embedded within the thermal mass shall be cold-expansion compression-sleeve fittings. Note: Fittings located in the thermal mass shall be limited to tubing repairs only. The standard installation shall have no joints embedded in the thermal mass.

## 2.3 MANIFOLDS

- A. Material: Distribution manifolds shall be manufactured of brass, bronze, high temperature reinforced and stabilized plastic or copper and be supplied by the piping manufacturer as a proven cataloged part of the manufacturer's system.
- B. Balancing Manifolds: Manifolds shall be equipped with visual flow gauges, balancing and isolation valves for each circuit, header isolation valves and fill ports.

## 2.4 MANIFOLD ACCESS PANELS

- A. Access panels shall be provided under Division 08000. Panels shall be minimum 36" wide x 30" high. Provide larger size as required to provide access to the entire manifold and associated components.

## 2.5 CONTROLS

### A. CENTRAL DDC CONTROLLERS

1. The controls for the floor heating system shall be provided under Section 15900 and the Sequence of Operation listed in the drawings. The DDC controller shall be a P-I-D type and shall calculate the system supply water temperature based on the floor heating system reset schedule.
2. The DDC interface to the snowmelt system shall include an activate/deactivate signal and shall receive a 4-10 mA signal from the snowmelt controller.

### B. SNOWMELT CONTROLLER

1. The snowmelt controller shall be Tekmar Model 664 or approved equal. The controller shall provide complete control of the snow melting system and shall produce a 4-20 mA signal to the BAS/DDC controller to operate the heat exchanger control valve. The controller shall be started by the BAS and shall be stopped after the BAS has timed out or if the slab sensor no longer detects the presence of water/snow/ice for at least 30 minutes. The controller shall provide a slab 'soft start' to prevent overstressing the snowmelt slab. Additionally, the viscosity compensation feature shall be activated to reduce the pump operating start-up head requirements.
  - a. Provide a Tekmar Model 090 or approved equal Snow/Ice Sensor and necessary components to install the sensor in the slab material. Configure equipment so that it is replaceable without disturbing the snowmelt surface.

### C. PIPING ARRANGEMENT

1. The system shall be plumbed in a primary/secondary arrangement. The two way modulating valve shall inject high temperature boiler water into the continuously circulating radiant floor heating loop. The system shall be configured with space loop control valves capable of controlling loop water flow at the manifold in accordance with the zoning on the drawing schedules.

### D. MANIFOLD CIRCUIT VALVES (RADIANT FLOOR )

1. The manifold circuit valves shall be quiet, 24 VAC, normally open and manually operable to override control signal or valve actuator failure. The valve close off pressure shall be 50 PSI. The basis of design is Danfoss Type ABNV. Supply valves only on loops that are indicated on the drawings as needing a valve.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Concrete Slab on Grade: Sub-grade should be compacted, flat and smooth to prevent damage to pipe or insulation. Approved vapor barrier material shall be installed. Finished grade of the thermal mass must be a minimum of 3/4" (19 mm) above the top of PEX heating pipes.

- B. Preparation of wall cavity for manifold installation: See drawings to determine the width of the wall cabinet and required wall opening dimensions. Mount the manifold cabinet allowing space for the screed to fill up the front of the pipe opening. Manifold shall be installed in an area that will allow easy access for supply/return piping as well as future access for maintenance.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's published installation manual and/or published guidelines.
- B. Provide ½" flexible elastomeric foam insulation over tubing in areas of high tubing density where excessive floor and/or space temperatures are expected and as indicated on the drawings. This is likely to occur at areas immediately adjacent to manifolds.
- C. Route piping in orderly manner, according to layout and spacing shown in approved submittal drawings. Piping shall not be located beneath partitions or walls of the project. Where tubing must pass beneath partitions or walls, the tubing shall traverse at right angles to the partition or wall. Wall and partition traverses shall be limited to two for each tubing loop. Tubing spacing shall not exceed 12" center to center.
- D. At connections and fittings, use a plastic pipe cutter to ensure square and clean cuts, and join pipes immediately or cap ends of pipe to seal from contaminants. Tubing shall be installed continuous in the slab and shall contain no joint or connections within the slab.
- E. Pipe shall be dispensed using a suitable uncoiling device. Remove twists before securing pipe. Pipe must lay flat on an even plane. Finished grade of a thermal mass must be a minimum of ¾" (19 mm) above the top of PEX heating pipes. Fasten piping using nylon tie straps at intervals less than 3-feet (90 cm) intervals, being careful not to twist the tubing. In thin concrete slabs (less than 4 inches thickness), secure piping every 2 feet (60 cm). Use only fasteners supplied or approved by the manufacturer of the PEX pipe.
- F. Piping that passes through expansion joints in heavy weight concrete shall drop below the slab 12 inches before the joint and re-enter the slab 12" beyond the joint. Piping located below the slab shall be insulated with ½" flexible elastomeric foam insulation.
- G. Where piping exits the thermal mass, a protective conduit shall be placed around the pipe, with the conduit extending a minimum of 6 inches (15 cm) into the floor and exiting by a minimum of 6 inches. For penetrations at manifolds, use rigid PVC bend guides or PVC preformed long radius conduit bends secured in place to prevent movement.
- H. At the time of installation of each circuit of pipe, connect the pipe to the correct manifold outlet and record pipe length for balancing. If manifold is not installed, cap the end of the pipe and label the pipe circuit number along with S for supply and R for return. Connect pipes to manifold as soon as possible, and record circuit lengths. Each circuit shall be labeled to indicate circuit length and area serviced with brass or plastic tags clearly marked with minimum ¼" high lettering. Include this information in the operations and maintenance manuals.
- I. Prior to pouring of the concrete the radiant floor tubing array shall be connected to the manifolds and an air pressure of 100 PSI charged into the system. The air pressure shall be maintained for a minimum of two days before pouring the slab. During the slab pour, the pressure at each manifold shall be carefully observed. Loss of pressure shall immediately stop the pour and the location of the leak/failure shall be determined. A suitable splice shall be installed or the pour stopped to allow the proper corrective action to take place at a later time. Suitable pour stops may be installed in the damaged tube area to allow repair of the tubing following the pour. In the event that the pour is to continue without immediately repairing the

broken tube, the manifold valves for the damaged loop shall be closed and the air pressure reapplied to the remainder of the system.

- J. The following precautions shall be taken in areas intended for carpet:
  - 1. Notify carpet installer that radiant heating pipes have been installed.
  - 2. Keep pipes 6 inches (15 cm) from wall base plates.
  - 3. Install metal guards where pipe will pass through wall base plates and where carpet tack strips will be installed.
  
- K. The heating system shall not be put into operation until the poured concrete thermal mass has cured a minimum of 28 days, unless otherwise specified and approved by the thermal mass supplier. If it is necessary to operate the heating system to prevent freezing, a maximum flow temperature of 72 degrees F (22°C) shall not be exceeded while the thermal mass is curing. After curing, gradually increase the flow temperature by no more than 10 degreesF (6°C) each day until system reaches the required operating temperature.
  
- L. Preparation of heating slab for floor materials installation.
  - 1. During heating season the radiant heating system shall be activated for a minimum of two weeks prior to the installation of the floor coverings. During a period other than heating season the radiant system shall be configured to maintain a slab temperature of 70 degrees F for a minimum of two weeks prior to installation of the floor coverings.

### 3.3 FIELD QUALITY CONTROL

- A. Filling, Testing & Balancing: Tests of hydronic heating systems shall comply with local codes, and, where required, shall be witnessed by the building official and/or the project engineer.
  
- B. Pressure gauges used shall show pressure increments of 1 PSIG and shall be located at or near the lowest points in the distribution system.
  
- C. Water Test
  - 1. Purge air from tubing, piping and other system components. Charge the completed, yet visible pipes with water. Take necessary precautions to prevent water from freezing. Check the system for leakage, especially at pipe joints.
  - 2. Perform a preliminary pressure test pressurizing the system to 100 PSI for 30 minutes. As the piping expands, restore pressure, first at 10 minutes into the test and again at 20 minutes. At the end of the 30-minute preliminary test, pressure must not fall by more than 8 PSIG from the maximum, and there shall be no leakage.
  - 3. After performing the preliminary test, perform the main pressure test immediately. The main pressure test shall last 2 hours. The test pressure shall be restored and must not fall more than 3 PSIG after 2 hours. No leakage shall be detected.
  - 4. Pressure shall be maintained and monitored during installation of the thermal mass. If any leak is detected during installation of thermal mass, the leak must be found immediately and the area cleared for repair using manufacturer-approved repair coupling. Retest before covering repair.
  
- D. The radiant system installer shall provide start up services to ensure proper and complete operation of the system. The installer shall include up to two return visits during the warranty

period for fine adjustment of the system. Adjustments shall be coordinated with the Owner and the engineer as written documentation of intended and actual adjustments made to the system.

- E. Complete inspection and test reports as supplied by the manufacturer of the system. Submit the inspection and test reports to the engineer for review and incorporate copies into the operation and maintenance manuals for the system.
- F. Provide detailed information regarding the system in the operations and maintenance manuals. The manuals shall include set points, controls schematics, tubing layouts, manifold configurations and settings, product data and any other pertinent information regarding the system.

**END OF SECTION 15774**



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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the 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 10 inch w.g. Metal ducts include the following:
  - 1. Rectangular ducts and fittings.
  - 2. Single-wall, round spiral and longitudinal seam ducts and formed fittings.
  - 3. Duct liner.
- B. Related Sections include the following:
  - 1. Division 7, "Through-Penetration Fire Stop Systems" for materials and methods for sealing duct penetrations through fire and smoke barriers.
  - 2. Division 7, "Joint Sealants" for materials and methods for sealing duct penetrations through exterior walls.
  - 3. Section 15820 "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.
- B. NUSIG: National Uniform Seismic Installation Guidelines.
- C. SMACNA – Sheet Metal and Air Conditioning Contractors' National Association, Inc. – latest edition.

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 Architect. Accompany requests for layout modifications with calculations showing that the proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

- A. General: See Division 1 for general submittal and product substitution requirements.
- B. Pre-construction Shop Drawings: Show fabrication and installation details for metal ducts as follows prior to commencing with fabrication and installation:
  - 1. Metal gages.
  - 2. Fittings.
  - 3. Reinforcement and spacing.
  - 4. Seam and joint construction.
  - 5. Penetrations through fire-rated and other partitions.
  - 6. Equipment installation based on equipment being used on Project.
  - 7. Duct accessories, including access doors and panels.
- C. 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Duct liner
    - a. Nomaco K-Flex.
    - b. Armacell.
  - 2. Transverse joints
    - a. Ductmate Industries, Inc.

- b. Nexus Inc.
- c. Ward Industries, Inc.
  
- 3. Round duct and fittings
  - a. McGill AirFlow Corporation.
  - b. SEMCO Incorporated.
  - c. Monroe Metal Mfg. Co.
  
- 4. Duct joints – round ducts
  - a. Ductmate Industries, Inc.
  - b. Lindab Inc
  
- 5. Cable Duct Hangers
  - a. GRIPPLE “Hang Fast”

## 2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
  
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653 and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
  
- C. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
  
- D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

## 2.3 DUCT LINER

- A. Elastomeric Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124. Note: Fiberglass containing products are not acceptable
  - 1. Materials:
    - a. Flexible Duct Liner: Basis of Design is Nomaco K-Flex
      - 1) Thickness: 1 inch
      - 2) Thermal Conductivity (k-Value): 0.27 at 75 deg F mean temperature.
      - 3) Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
      - 4) Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
      - 5) Mechanical Fasteners: Galvanized steel suitable for mechanical attachment or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct. Fasteners with “peel and stick” adhesive are not acceptable.
        - a) Tensile Strength: Indefinitely sustain a 50-lb tensile, dead load test perpendicular to duct wall.

- b) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into air stream.
  - c) Adhesive for Attaching Mechanical Fasteners: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
2. Round Duct Liner: ASTM C 1071; surfaces exposed to air stream shall be coated to prevent erosion of the fibers.
- a. Thickness: 1 inch
  - b. Thermal Conductivity (k-Value): 0.27 at 75 deg F (0.037 at 24 deg C) 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.
3. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

#### 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 or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
  - 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
  - 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
  - 3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
- 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.
  - 1. Supports for Galvanized Steel Ducts: Galvanized-steel shapes and plates.
  - 2. Supports for Stainless Steel Ducts: Stainless-steel support materials.
  - 3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.
- E. At contractors option, ductwork shall be properly suspended or supported from the building structure utilizing an approved cable hanging system. The duct hanging system shall comprise a

pre-formed cable sling and the load rated fastener for cable length adjustment. The hanger system for ductwork shall be in accordance with Figs 4.1 through 4.8 and tables 4.1 through 4.3 of the 1995 SMACNA Duct Construction Standards Manual. Hanger system shall be load rated and incorporate a 5 to 1 safety factor, and be plenum rated. Stress distribution saddles shall be applied at corners on rectangular duct as required by the manufacturer.

## 2.6 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
  - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
  - 2. 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.
- C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
- D. 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 non-braced panel area unless ducts are lined.

## 2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Duct liner of the specified material and thickness shall be furnished and installed where shown on the drawings. The duct dimensions indicated on the drawings are the net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.
- B. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- C. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- D. Butt transverse joints without gaps and coat joint with adhesive.
- E. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- F. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the air stream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
  - 1. Fan discharges.
  - 2. Intervals of lined duct preceding unlined duct.
  - 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
- I. Terminate inner ducts with build-outs attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated build-outs (metal hat sections) or other buildout means are optional; when used, secure build-outs to duct walls with bolts, screws, rivets, or welds.

## 2.8 ROUND DUCT AND FITTING FABRICATION

- A. Manufacture in accordance with SMACNA HVAC Duct Construction Standards and as indicated. Provide duct material, gauges, reinforcement, and sealing for operating pressures indicated.
- B. All duct and fittings shall be manufactured by a company whose primary business is the manufacture of spiral duct and fittings and who has been in business for at least 10 years. All spiral duct and fittings shall be manufactured by the same firm and shall be as shown on the contract drawings.
- C. Round, Longitudinal and Spiral Lock Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Duct Joints:
  - 1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
  - 2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
  - 3. Round Ducts: Prefabricated connection system consisting of two roll-formed galvanized steel mating flanges with an integral sealant, galvanized steel closure ring, and neoprene gasket. Manufacture ducts according to connection system manufacturer's tolerances.
- E. Branch connections shall be made with 90 degree conical and 45 degree straight taps. All branch connections shall be made as separate fittings. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

- G. 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. Unless elbow construction type is indicated, fabricate elbows as follows:
1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible.
  2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2 to plus 2 inch w.g.:
    - a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
  3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch w.g.:
    - a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
  4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
  5. Round Elbows 12 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
  6. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
  7. Round Elbows Larger Than 14 Inches in Diameter: Fabricate gored elbows unless space restrictions require mitered elbows.
  8. Die-Formed Elbows for Sizes through 12 Inches in Diameter and pressures through 10 inch w.g.: 24 gauge with 2-piece welded construction.
  9. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
  10. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch w.g.: 0.022 inch.
  11. Elbows located downstream of VAV boxes, final diffuser/grille connections, low pressure application may be segmented adjustable types provided that the turning radius is 1.5 times the duct diameter and all duct seams are sealed per specification.

### PART 3 - EXECUTION

#### 3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply Ducts: 3-inch w.g.
  2. Supply Ducts (before Air Terminal Units): 6-inch w.g.
  3. Supply Ducts (after Air Terminal Units): 1-inch w.g. .
  4. Return Ducts (Negative Pressure): 2-inch w.g. .
  5. Exhaust Ducts (Negative Pressure): 1-inch w.g.

6. Relief Ducts (Positive Pressure): 1-inch w.g.
7. Outside Air Intake: 1-inch w.g.

B. All ducts shall be galvanized steel except as follows:

1. Shower/Locker Room Exhaust Ducts: Aluminum or Type 304 stainless steel

### 3.2 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round ducts in lengths not less than 12 feet unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of three screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- I. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- J. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- K. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- L. 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.
- M. Fire Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and fire stopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Fire stopping materials and installation methods are specified in Division 7 Section "Through Penetration Fire stop Systems."



- N. Protect duct interiors from the elements and foreign materials until building is enclosed. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust and debris from entering the ductwork system.
- O. 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. Paint materials and application requirements are specified in Division 9 painting Sections.
- P. For internally lined ducts, provide sheet metal nosing at the leading edges of liner continuous around the duct perimeter. Secure nosing to the duct with sheet metal screws, rivets or spot welding at 6" maximum spacing. Nosing shall extend a minimum of 3" over the duct liner. Fully adhere liner to the nosing and duct. If sheet metal screws are used to fasten nosing, cover fasteners outside of the duct with a generous coating of duct sealant.

### 3.3 SEAM AND JOINT SEALING

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure classes as outlined below.
  - 1. Supply Ducts – pressure classes equal to or lower than 2-inch w.g.:
    - a. For ducts located in conditioned spaces: seal transverse joints.
    - b. For ducts located in unconditioned spaces: seal all transverse joints and longitudinal seams.
    - c. For ducts located outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
  - 2. Supply Ducts – pressure classes greater than 2-inch w.g.:
    - a. For ducts located in conditioned spaces: seal all transverse joints and longitudinal seams.
    - b. For ducts located in unconditioned spaces and outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
  - 3. Return Ducts, all pressure classes:
    - a. For ducts located in conditioned spaces: seal transverse joints.
    - b. For ducts located in unconditioned spaces: seal all transverse joints and longitudinal seams.
    - c. For ducts located outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
  - 4. Exhaust ducts:
    - a. For ducts located in conditioned spaces: seal all transverse joints and longitudinal seams.
    - b. For ducts located in unconditioned spaces: seal all transverse joints only.
- 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. Support vertical ducts at maximum intervals of 16 feet and at each floor.

- C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- D. Install concrete inserts before placing concrete.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

**END OF SECTION 15815**

SECTION 15820

DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 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 13, Section 13851 "Fire Alarm" for duct-mounting fire and smoke detectors.
  - 2. Division 15, Section 15900 "HVAC Instrumentation and Controls" for electric and pneumatic damper actuators.

1.3 SUBMITTALS

- A. Product Data: For 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.

- 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.
  - 2. Manual-volume damper installations.
  - 3. Fire-damper installations, including sleeves and duct-mounting access doors.
  - 4. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

#### 1.4 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Backdraft dampers
    - a. American Warming and Ventilating.
    - b. CESCO Products.
    - c. Duro Dyne Corp.
    - d. Greenheck.
    - e. Ruskin Company.
  - 2. Volume dampers
    - a. Air Balance, Inc.
    - b. American Warming and Ventilating.
    - c. McGill AirFlow Corporation.
    - d. METALAIRE, Inc.
    - e. Nailor Industries Inc.
    - f. Ruskin Company.
  - 3. Fire dampers
    - a. CESCO Products.
    - b. Greenheck.
    - c. METALAIRE, Inc.
    - d. Nailor Industries Inc.
    - e. Ruskin Company.

4. Manufactured turning vanes
  - a. Ductmate Industries, Inc.
  - b. Duro Dyne Corp.
  - c. METALAIRE, Inc.
  
5. Duct-mounting access doors – rectangular
  - a. American Warming and Ventilating.
  - b. CESCO Products.
  - c. Ductmate Industries, Inc.
  - d. Flexmaster U.S.A., Inc.
  - e. Greenheck.
  - f. McGill AirFlow Corporation.
  - g. Nailor Industries Inc.
  
6. Duct-mounting access doors – round
  - a. Ductmate Industries, Inc.
  - b. Flexmaster U.S.A., Inc.
  
7. Flexible connectors
  - a. Ductmate Industries, Inc.
  - b. Duro Dyne Corp.
  - c. Ventfabrics, Inc.
  - d. Ward Industries, Inc.
  
8. Flexible ducts
  - a. Flexmaster U.S.A., Inc.
  - b. Hart & Cooley, Inc.
  - c. McGill AirFlow Corporation.

## 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 G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
  
- C. Stainless Steel: ASTM A 480/A 480M.
  
- D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
  
- E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.
  
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

- G. 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 BACKDRAFT DAMPERS

- A. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.
- B. Frame: 0.052-inch thick, galvanized sheet steel or 0.063-inch thick extruded aluminum, with welded corners and mounting flange. Material shall match duct work construction.
- C. Blades: 0.050-inch thick aluminum sheet.
- D. Blade Seals: Neoprene.
- E. Blade Axles: Galvanized steel.
- F. Tie Bars and Brackets: Galvanized steel.
- G. Return Spring: Adjustable tension.

### 2.4 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, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
  - 1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
  - 2. Roll-Formed Steel Blades: 0.064-inch thick, galvanized sheet steel.
  - 3. Blade Axles: Galvanized steel.
  - 4. Bearings: Oil-impregnated bronze.
  - 5. Tie Bars and Brackets: Aluminum.
  - 6. Tie Bars and Brackets: Galvanized steel.
- 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.

1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
  2. Roll-Formed Steel Blades: 0.064-inch thick, galvanized sheet steel.
  3. Blade Axles: Galvanized steel.
  4. Bearings: Oil-impregnated bronze thrust or ball.
  5. Blade Seals: Neoprene.
  6. Jamb Seals: Cambered stainless steel.
  7. Tie Bars and Brackets: Galvanized steel.
- D. Jackshaft: 1-inch diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
- E. 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.

## 2.5 FIRE DAMPERS

- A. Fire dampers shall be labeled according to UL 555.
- B. Fire Rating: 1-1/2 hours.
- C. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.
- D. 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.
- E. Mounting Orientation: Vertical or horizontal as indicated.
- F. 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.
- G. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- H. Fusible Links: Replaceable, 165 deg F rated.

2.6 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate 1-1/2-inch wide, **single-vane**, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

2.7 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.
  - 2. Provide number of hinges and locks as follows:
    - a. Less Than 12 Inches Square: Secure with two sash locks.
    - b. Up to 18 Inches Square: Two hinges and two sash locks.
    - c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
    - d. Sizes 24 by 48 Inches and Larger: One additional hinge.
- C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.
  - 1. Frame: Galvanized sheet steel, with spin-in notched frame.
- 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.

2.8 FLEXIBLE CONNECTORS

- A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- B. 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.
- C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd.
  - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F.



- D. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
  - 1. Minimum Weight: 24 oz./sq. yd.
  - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
  - 3. Service Temperature: Minus 50 to plus 250 deg F.

## 2.9 FLEXIBLE DUCTS

- A. Insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring steel wire; fibrous glass insulation; polyethylene 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 deg F.
- B. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

## 2.10 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

## PART 3 - EXECUTION

### 3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- 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.

- F. Provide test holes at fan inlets and outlets and elsewhere as indicated.
  - G. Install fire dampers, with fusible links, according to manufacturer's UL-approved written instructions.
  - H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
    - 1. On both sides of duct coils.
    - 2. Downstream from volume dampers, turning vanes, and equipment.
    - 3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
    - 4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
    - 5. On sides of ducts where adequate clearance is available.
  - I. Install the following sizes for duct-mounting, rectangular access doors:
    - 1. One-Hand or Inspection Access: 8 by 5 inches.
    - 2. Two-Hand Access: 12 by 6 inches.
    - 3. Head and Hand Access: 18 by 10 inches.
    - 4. Head and Shoulders Access: 21 by 14 inches.
  - J. Install the following sizes for duct-mounting, round access doors:
    - 1. One-Hand or Inspection Access: 8 inches in diameter.
    - 2. Two-Hand Access: 10 inches in diameter.
    - 3. Head and Hand Access: 12 inches in diameter.
  - K. Label access doors according to Division 15 Section "Mechanical Identification."
  - L. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
  - M. Connect terminal units to supply ducts directly.
  - N. Connect diffusers boots to low pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
  - O. Connect flexible ducts to metal ducts with draw bands.
  - P. 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 15950 "Testing, Adjusting, and Balancing."

END OF SECTION 15820



SECTION 15838

POWER VENTILATORS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following:
  - 1. Centrifugal roof ventilators.
  - 2. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base air ratings on sea-level conditions.
- B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
  - 1. Certified fan performance curves with system operating conditions indicated.
  - 2. Certified fan sound-power ratings.
  - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - 4. Material gages and finishes, including color charts.
  - 5. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

#### 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

#### 1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

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

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

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

- 1. Centrifugal Roof Ventilators:

- a. Aerovent; a Twin City Fan Company.
- b. Ammerman Company, Inc./General Resource Corp.
- c. Cook, Loren Company.
- d. Greenheck Fan Corp.
- e. Hartzell Fan, Inc.
- f. JennFan; Div. of Breidert Air Products, Inc.
- g. Penn Ventilation Companies, Inc.
- h. Quietaire Corp.

- 2. In-Line Centrifugal Fans:

- a. Barry Blower Div./Penn Ventilation Companies, Inc.
- b. Bayley Fans, Lau Commercial Industrial Fans/Lau Industries.
- c. Cook, Loren Company.
- d. Greenheck Fan Corp.
- e. Hartzell Fan, Inc.
- f. JennFan; Div. of Breidert Air Products, Inc.
- g. Penn Ventilation Companies, Inc.
- h. Quietaire Corp.

2.2 CENTRIFUGAL ROOF VENTILATORS

- A. Basis of design: Loren Cook ACE.
- B. Description: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
- D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
  - 1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
  - 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.

4. Fan and motor isolated from exhaust airstream.

F. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in cant and mounting flange
2. Overall Height: 18 inches.
3. Metal Liner: Galvanized steel.
4. Hinged Subbase: Galvanized steel hinged arrangement permitting service and maintenance. Provide tamper resistant fasteners and associated tools required for maintenance access.
5. Mounting Pedestal: Galvanized steel with removable access panel.

## 2.3 IN-LINE CENTRIFUGAL FANS

A. Basis of Design: Loren Cook "Gemini" series fans.

B. Description: In-line, direct drive centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

C. Housing: Injection molded from specifically engineered resin exceeding UL requirements for smoke and heat generation.

D. Direct-Driven Assembly: Resiliently mounted to the housing, with the following features:

E. Fan Wheels: Centrifugal forward curve type, injection molded of polypropylene resin. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.

F. Accessories:

1. Backdraft Damper: Aluminum with continuous aluminum hinge rod located in fan outlet.
2. Companion Flanges: For inlet and outlet duct connections.
3. Aluminum wall cap sized for fan discharge.



2.4 MOTORS

- A. Comply with requirements in Division 15 Section "Motors."
- B. Enclosure Type: Guarded dripproof.

2.5 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

**PART 3 - EXECUTION**

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.
- C. Support suspended units from structure using threaded steel rods and elastomeric hangers. Vibration-control devices are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
- D. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
7. Disable automatic temperature-control operators.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

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

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

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

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

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

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

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.5 CLEANING

- A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.
- B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain power ventilators.
  - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
  - 2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
  - 3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  - 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

**END OF SECTION 15838**



SECTION 15840

AIR TERMINAL UNITS

**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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

- A. This Section includes the following:
  - 1. Single-duct air terminal units.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Closeout Procedures," include the following:
  - 1. Instructions for resetting minimum and maximum air volumes.
  - 2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

#### 1.5 COORDINATION

- A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Single-Duct Air Terminal Units
    - a. Anemostat; a Mestek Company.
    - b. Environmental Technologies, Inc.; Enviro-Air Div.
    - c. Nailor Industries of Texas Inc.
    - d. Price Industries.
    - e. Titus.
    - f. Trane Co. (The); Worldwide Applied Systems Group

#### 2.2 SINGLE-DUCT AIR TERMINAL UNITS

- A. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- B. Casing: 0.034-inch steel.
  - 1. Casing Lining: 1-inch thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil and solid metal.
  - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
  - 3. Air Outlet: S-slip and drive connections.
  - 4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
- C. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
  2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
  2. Damper Position: Normally open.
- E. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

### 2.3 SOURCE QUALITY CONTROL

- A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.
- B. Verification of Performance: Rate air terminal units according to ARI 880.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

### 3.2 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 air terminal units to allow service and maintenance.
- C. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- D. Connect ducts to air terminal units according to Division 15 Section "Metal Ducts."
- E. Connect wiring according to Division 16 Section "Conductors and Cables."
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
  - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

3.4 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 and do the following:
    - a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
    - b. Verify that controls and control enclosure are accessible.
    - c. Verify that control connections are complete.
    - d. Verify that nameplate and identification tag are visible.
    - e. Verify that controls respond to inputs as specified.

3.5 DEMONSTRATION

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

**END OF SECTION 15840**



**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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the 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 15820 "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. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Grilles and registers – adjustable bar
    - a. Anemostat; a Mestek Company.
    - b. Krueger.

- c. METALAIRE, Inc.; Metal Industries Inc.
  - d. Nailor Industries of Texas Inc.
  - e. Price Industries.
2. Linear slot diffuser
    - a. Anemostat; a Mestek Company.
    - b. Krueger.
    - c. METALAIRE, Inc.; Metal Industries Inc.
    - d. Nailor Industries of Texas Inc.
    - e. Price Industries.
  3. Rectangular and square ceiling diffusers
    - a. Anemostat; a Mestek Company.
    - b. Krueger.
    - c. METALAIRE, Inc.; Metal Industries Inc.
    - d. Nailor Industries of Texas Inc.
    - e. Price Industries.
  4. Louver face diffuser
    - a. Anemostat; a Mestek Company.
    - b. Krueger.
    - c. METALAIRE, Inc.; Metal Industries Inc.
    - d. Nailor Industries of Texas Inc.
    - e. Price Industries.

## 2.2 GRILLES AND REGISTERS

### A. Adjustable Bar Grille or Register:

1. Basis of Design: Price Model 535
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Fixed horizontal spaced 1/2 inch apart.
5. Rear Blade Arrangement: Fixed vertical spaced 1/2 inch apart.
6. Frame: Panel mounted for lay in ceiling or counter-sunk screws for surface mounting as shown on drawings.

## 2.3 LINEAR SLOT OUTLETS

### A. Basis of Design: Price Model SDA

1. Type: Continuous slot, with adjustable pattern controller for 180-degree adjustment of the discharge direction, as well as volume control, all from the face of the diffuser. Slot widths and quantities as scheduled.
2. Fabrication: Steel with factory white baked enamel finish.
3. Frame: 1" margin with support clips for T-bar mounting or border for surface mount as scheduled.
4. Mounting: Lay-in or countersunk screw for surface mounting as indicated on the drawings.
5. Plenum: Integral, galvanized steel, insulated.

2.4 CEILING DIFFUSER OUTLETS

A. Rectangular and Square Ceiling Diffusers:

1. Basis of Design: Price Model SMCD and SPD as scheduled.
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Pattern (model SMCD): One-way, Two-way, Three-way, or Four-way, core style as shown on the drawings.
5. Mounting: Panel mount lay-in or countersunk screw for surface mounting as indicated on the drawings.

B. Louver Face Diffuser:

1. Basis of Design: Price Model 535
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Mounting: Counter-sunk screws for surface mounting.

2.5 ROUND DUCT DIFFUSERS

A. Duct Diffusers:

1. Basis of Design: Price Model RDR.
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Mounting: Countersunk screw for duct mounting.

2.6 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.

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. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts.
- D. Frames for diffusers, registers and grilles shall be selected to match the ceiling type. Air devices installed in a suspended acoustic tile ceiling shall be provided with a lay-in metal panel matched to the air device finish and material and shall fit in the grid dimensions. Cutting ceiling tiles for installation is not acceptable.

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 15855**

SECTION 15856

INTAKE AND RELIEF VENTILATORS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

- A. This Section includes the following types of roof-mounting intake and relief ventilators:
  - 1. Roof hoods.

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Intake and relief ventilators shall be capable of withstanding the effects of gravity loads, wind loads, seismic loads, and thermal movements without permanent deformation of components, noise or metal fatigue, or permanent damage to fasteners and anchors.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated
- B. Shop Drawings: For intake and relief ventilators. Include plans, elevations, sections, details, and ventilator attachments to curbs and curb attachments to roof structure.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain ventilators through one source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of intake and relief ventilators and are based on the specific equipment indicated. Refer to Division 1 Section "Product Requirements."

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

1.6 COORDINATION

- A. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

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

1. Roof Hoods:
  - a. Aerovent; a Twin City Fan company.
  - b. Greenheck.
  - c. Loren Cook Company.
  - d. Penn Ventilation.

2.2 ROOF HOODS

- A. Type: Intake or relief with sizes and performance as scheduled on drawings.
- B. Materials: 14-gauge marine alloy aluminum bolted to minimum 8-gauge support.
- C. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
  1. Configuration: Built-in cant and mounting flange.
  2. Overall Height: 24 inches.
- D. Bird Screening: Galvanized-steel, 1/2-inch square mesh, 0.041-inch wire.
- E. Accessories:
  1. Provide hinged base
  2. Provide insulated motorized dampers as specified in Section 15820 "Duct Accessories".

**PART 3 - EXECUTION**

3.1 INSTALLATION

- A. Install intake and relief ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure intake and relief ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.
- C. Install intake and relief ventilators with clearances for service and maintenance.
- D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Label intake and relief ventilators according to requirements specified in Division 15 Section "Mechanical Identification."
- F. Coordinate installation of insulated motorized dampers.

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories.

3.3 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

**END OF SECTION 15856**





SECTION 15900

HVAC INSTRUMENTATION AND CONTROLS

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.
- B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.
- C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 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 16, Section 16700 "Fire Alarm" for fire and smoke detectors mounted in HVAC systems and equipment.

1.3 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. LAN: Local area network.
- C. MS/TP: Master-slave/token-passing.
- D. PICS: Protocol Implementation Conformance Statement.

1.4 SYSTEM DESCRIPTION

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

- C. Boiler plant controller to be provided by the boiler manufacturer/supplier as indicated in specification section 15513.
- D. Chiller plant controller to be provided by chiller manufacturer/supplier as indicated in specification section 15626 and 15628.
- E. Control system includes the following:
  - 1. Fire alarm system specified in Division 16, Section 16700 "Fire Alarm."

#### 1.5 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. Each control device labeled with setting or adjustable range of control.
- 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. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
  - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
  - 3. Details of control panel faces, including controls, instruments, and labeling.
  - 4. Written description of sequence of operation.
  - 5. Schedule of dampers including size, leakage, and flow characteristics.
  - 6. Schedule of valves including leakage and flow characteristics.
  - 7. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
  - 8. Listing of connected data points, including connected control unit and input device.
  - 9. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
  - 10. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- C. ASHRAE BACnet Statement: PICS for each DDC system component (panel, zone controller, field devices, and operator workstation) proposed.
- D. Software and Firmware Operational Documentation: Include the following:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
  - 3. Device address list.
  - 4. Printout of software application and graphic screens.
  - 5. Software license required by and installed for DDC workstations and control systems.

- E. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.
- F. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- G. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:
  - 1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
  - 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.
- H. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- I. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

#### 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those indicated for this Project and with a record of successful in-service performance.
- 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. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
- E. Comply with ASHRAE 135 for DDC system control components.

#### 1.7 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 unit manufacturer.

1.8 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment with Division 16 Section "Lighting Controls" to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate equipment with Division 16 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.
- D. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
- E. Coordinate equipment with Division 16 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.
- F. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

1.9 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.
- B. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat, positioning relay.

1.10 EXCLUSIONS

- A. Mercury containing products and materials are not permitted to be used for any of the controls functions indicated herein.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Control Systems Components:
    - a. Belimo Aircontrols (USA), Inc.
    - b. CEA Instruments Inc.
    - c. Ebtron, Inc.
    - d. Erie Controls.
    - e. Functional Devices Inc.
    - f. Greystone Energy Systems Inc.
    - g. Honeywell, Inc.; Home & Building Control.

- h. Invensys Building Systems, Inc.
  - i. Johnson Controls, Inc.; Controls Group.
  - j. Parker Hannifin Corp.; Skinner Valve Division.
  - k. TCS/BASYS Controls; HVAC Sensors & Transducers Division.
  - l. Texas Instruments, Inc.; Commercial Sensors & Controls.
  - m. TSI Inc.; Environmental Measurements & Controls Div.
  - n. Uni-Line North America; Robertshaw Division.
  - o. Valvcon Corporation.
  - p. Vent Products Co., Inc.
2. Electric, Electronic, and DDC Systems:
- a. Alerton Technologies, Inc.
  - b. Andover Controls Corp.
  - c. CSI Control Systems International, Inc.
  - d. Danfoss Automatic Controls.
  - e. Honeywell, Inc.; Home & Building Control.
  - f. Invensys Building Systems, Inc.
  - g. Johnson Controls, Inc.; Controls Group.
  - h. Siebe Environmental Controls; Barber-Coleman/Robertshaw Products.
  - i. TCS/BASYS Controls; HVAC Sensors & Transducers Division.
  - j. Trane Co. (The); North American Commercial Group.

## 2.2 DDC EQUIPMENT

- A. Operator Station: Microcomputer station with printer.
- B. Workstation: IBM-compatible microcomputer with minimum configuration as follows:
  - 1. Random-Access Memory: 1 GB.
  - 2. Graphics: Super video graphic adapter (SVGA), minimum 1280 x 1024 pixels, 2.0-MB EDO video memory.
  - 3. Monitor: 17 inches, noninterlaced, color, with maximum 0.28-mm dot pitch, LCD.
  - 4. Keyboard: QWERTY, 105 keys in ergonomic shape.
  - 5. Hard-Disk Drive: 4.0 GB.
  - 6. DVD Drive.
  - 7. Mouse: Three button.
  - 8. Modem: Autodial, internal, minimum 56 kBaud.
  - 9. Tape Backup: Internal, 56 kBps.
  - 10. Operating System: Microsoft Windows Vista Professional.
  - 11. BACnet Conformance: Workstation shall support BACnet device and have minimum capabilities defined in PICS for the following areas:
    - a. Network.
    - b. Functional groups.
    - c. Standard application services supported.
    - d. Standard objects supported.
- C. Printer: Color, ink-jet type as follows:

1. Print Head: 1440 x 1440 dpi photoquality color resolution.
  2. Internal Memory Buffer: 32 kB.
  3. Paper Handling: Minimum of 100 sheets.
  4. Print Speed: Minimum of 8 ppm in black and 4 ppm in color.
- D. Application Software: Include the following:
1. Input/output capability from operator station.
  2. Operator system access levels via software password.
  3. Database creation and support.
  4. Dynamic color graphic displays.
  5. Alarm processing.
  6. Event processing.
  7. Automatic restart of field equipment on restoration of power.
  8. Data collection.
  9. Graphic development on workstation.
  10. Maintenance management.
- E. 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 input/output point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator station.
  2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - a. Global communications.
    - b. Discrete/digital, analog, and pulse input/output.
    - c. Monitoring, controlling, or addressing data points.
    - d. Testing and developing control algorithms without disrupting field hardware and controlled environment.
  3. Local operator interface provides for download from or upload to mobile operator station.
  4. BACnet Conformance: Reside on BACnet LAN in Ethernet IEEE 802.3, Class 3, minimum, with routers between LAN and other panels, with at least one communication port, and have minimum capabilities defined in PICS for the following areas:
    - a. Network.
    - b. Functional groups.
    - c. Standard application services supported.
    - d. Standard objects supported.
- F. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
1. Units monitor or control each input/output point; process information; and download from or upload to operator station.
  2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

- a. Global communications.
  - b. Discrete/digital, analog, and pulse input/output.
  - c. Monitoring, controlling, or addressing data points.
3. Local operator interface provides for download from or upload to mobile operator station.
  4. BACnet Conformance: Reside on BACnet LAN using MS/TP, Class 2, minimum, with at least one communication port, and have minimum capabilities defined in PICS for the following areas:
    - a. Network.
    - b. Functional groups.
    - c. Standard application services supported.
    - d. Standard objects supported.
- G. LANs: Capacity for a minimum of 10 workstations connected to multiuser, multitasking environment with concurrent capability to access DDC network or control units.
1. Media: Ethernet, peer-to-peer CMA/CD, operating at 10 MBps.
  2. Media: ARCNET (attached resources computer network), peer to peer, operating at 2.5 MBps.
  3. Media: MS/TP, EIA 485, operating at 76.8 kBps.
- H. Software: Update to latest version of software at Project completion. Include and implement the following capabilities from the control units:
1. Units of Measure: Inch-pound and SI (metric).
  2. Load Control Programs: Duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, DDC with fine tuning, and trend logging.
  3. HVAC Control Programs: Optimal run time, building pressure control, demand control ventilation, and enthalpy switchover.
  4. Chiller Control Programs: Interface with chiller controls supplied by chiller manufacturer.
  5. Heating Plant Control: Interface with heating plant controls supplied by boiler manufacturer/supplier.
  6. Programming Application Features: Include trend point, alarm messages, weekly scheduling, and interlocking. Provide graphical representation of all systems.

## 2.3 CONTROL PANELS

- A. Central (Master) Control Panels: Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide multicolor graphic displays, schematically showing system being controlled.
- B. Local Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.
  1. Fabricate panels of 0.06-inch thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.

2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
  3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
  4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.
- C. Alarm Panels: Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted in hinged-cover enclosure.
1. Alarm Condition: Indicating light flashes and horn sounds.
  2. Acknowledge Switch: Horn is silent and indicating light is steady.
  3. Second Alarm: Horn sounds and indicating light is steady.
  4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
  5. Contacts in alarm panel allow remote monitoring by independent alarm company.

#### 2.4 ANALOG CONTROLLERS

- A. Step Controllers: Six- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
- B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.
- C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
  1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

#### 2.5 SENSORS

- A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
  1. Thermistor temperature sensors as follows:
    - a. Accuracy: Plus or minus 0.5 deg F at calibration point.
    - b. Wire: Twisted, shielded-pair cable.
    - c. Room Sensors: Match room thermostats, locking cover.
    - d. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
    - e. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
  2. Resistance Temperature Detectors: Platinum.



- a. Accuracy: Plus or minus 0.2 percent at calibration point.
  - b. Wire: Twisted, shielded-pair cable.
  - c. 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.
  - d. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
  - e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
  - f. Room Sensors: Match room thermostats, locking cover.
  - g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
  - h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
3. Humidity Sensors: Bulk polymer sensor element.
- a. Accuracy: 5 percent full range with linear output.
  - b. Room Sensors: With locking cover matching room thermostats, span of 25 to 90 percent relative humidity.
  - c. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
4. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
- a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
  - b. Output: 4 to 20 mA.
  - c. Building Static-Pressure Range: 0 to 0.25 inch wg.
  - d. Duct Static-Pressure Range: 0 to 5 inches wg.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- B. Equipment operation sensors as follows:
1. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
- C. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- D. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vaporproof type.
- E. Carbon-Monoxide Detectors: Single or multichannel, dual-level detectors, using solid-state sensors with 3-year minimum life, maximum 15-minute sensor replacement, suitable over a temperature range of 23 to 130 deg F, calibrated for 50 and 100 ppm, with maximum 120-second response time to 100-ppm carbon monoxide.

- F. Carbon-Dioxide Sensor and Transmitter: Single detectors, using solid-state infrared sensors, suitable over a temperature range of 23 to 130 deg F, calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output, and wall mounted.
- G. Room Sensors: Temperature sensor shall be either thermistor or RTD type as described above.
  - 1. The Sensor shall provide room temperature value and humidity to the controller.
  - 2. Each shall support a minimum of two sensors.
  - 3. There shall be at least one Sensor per floor wired so that the communication jack will provide for a connection to the native BACnet RS-485 or Lon communication trunk to which the controller is connected.
  - 4. The Sensor shall connect directly to the controller and shall not utilize any of the I/O points of the controller.
  - 5. The Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive.
  - 6. The Sensor shall be provided in a modular configuration that allows for the rough in of all wiring without the presence of the electronics or esthetic covering.
  - 7. The Sensor shall allow for the customization of the color on the esthetic covering as a standard offering.
- H. Room sensor accessories include the following:
  - 1. Insulating Bases: For thermostats located on exterior walls.
  - 2. Occupancy override

## 2.6 THERMOSTATS

- A. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
- B. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type, with adjustable set point in middle of range and adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.
- C. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
  - 1. Bulb Length: Minimum 20 feet.
  - 2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

## 2.7 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
  - 1. 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.
  - 2. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.

3. 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.
  4. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
- B. Electronic Damper and Large-Valve Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Valves: Size for torque required for valve close-off at maximum pump differential pressure.
  2. Dampers: Size for running torque calculated as follows:
    - a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
    - b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
    - c. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. of damper.
    - d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
    - e. Dampers with 2 to 3 Inches wg of Pressure Drop or Face Velocities of 1000 to 2500 FPM: Multiply the minimum full-stroke cycles above by 1.5.
    - f. Dampers with 3 to 4 Inches wg of Pressure Drop or Face Velocities of 2500 to 3000 FPM: Multiply the minimum full-stroke cycles above by 2.0.
  3. Coupling: V-bolt and V-shaped, toothed cradle.
  4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
  5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
  6. Power Requirements (Two-Position Spring Return): 24-V ac.
  7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
  8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
  9. Temperature Rating: Minus 22 to plus 122 deg F.
  10. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.

## 2.8 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. Globe Valves NPS 2 and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
- C. Globe Valves NPS 2-1/2 and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
- D. Hydronic system globe valves shall have the following characteristics:
  1. Rating: Class 125 for service at 125 psig) and 250 deg F operating conditions.
  2. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
    - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

- b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
  - 3. Sizing: 3-psig maximum pressure drop at design flow rate.
  - 4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.
- E. Steam system globe valves shall have the following characteristics:
- 1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
  - 2. Internal Construction: Replaceable plugs and seats of stainless steel.
    - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
    - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
  - 3. Sizing: -Pressure drop across steam valve at a maximum flow of 80 percent of inlet pressure for low-pressure systems and 42 percent for high-pressure systems.
  - 4. Flow Characteristics: Modified linear characteristics.
- F. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
- 1. Body Style: Lug or Grooved.
  - 2. Disc Type: Nickel-plated ductile iron or Aluminum bronze.
  - 3. Sizing: 1-psig maximum pressure drop at design flow rate.
- G. Terminal Unit Control Valves: Bronze body, bronze trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.
- 1. Rating: Class 125 for service at 125 psig and 250 deg F 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.
- 2.9 MOTORIZED CONTROL DAMPERS
- A. Thermally Insulated Dampers General Description: AMCA-rated, parallel for two position or opposed blade design for modulating dampers; minimum of 0.080-inch thick, extruded aluminum frames with flanges for duct mounting; insulated and thermally broken aluminum damper blades with maximum blade width of 6 inches.
- 1. Frame: Extruded aluminum, thermally broken with polyurethane resin pockets and thermal cuts.
  - 2. Blades: Extruded aluminum, internally insulated with R2.29 expanded polyurethane foam.
  - 3. Seals: Extruded silicon blade and frame seals secured in extruded aluminum slots. Seal material shall remain flexible down to -100 degree F.

4. Bearings: Celcon inner bearing fixed to a hexagon aluminum blade pin rotating in a polycarbonate outer bearing inserted in the frame.
  5. Linkage: Aluminum and zinc-plated steel concealed in the damper frame.
  6. Leakage: Air leakage rate shall be no greater than 4.9 CFM/SF at 4" water gauge pressure differential.
  7. Pressure Drop: Pressure drop through a fully open damper at 1000 fpm shall not exceed 0.03" water gauge.
  8. Basis of Design: Tamco Series 9000 ECT.
- B. Non-Thermally Insulated Dampers General Description: AMCA rated, parallel for two position or opposed blade design for modulating dampers; minimum of 0.1084-inch thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch thick, galvanized steel damper blades with maximum blade width of 8 inches.
1. Secure blades to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
  2. Operating Temperature Range: From minus 40 to plus 200 deg F.
  3. Provide parallel or opposed blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 6 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.
  4. Basis of Design: Ruskin CD-60.

## 2.10 CONTROL CABLE

- A. Electronic and Fiber-Optic Cable for Control Wiring: As specified in Division 16.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that duct-, pipe-, and equipment-mounted devices and wiring and pneumatic piping are installed before proceeding with installation.

### 3.2 INSTALLATION

- A. Install equipment level and plumb.
- B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- C. Connect and configure equipment and software to achieve sequence of operation specified.

- D. Verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate equipment at centerline height of 44 inches (1118 mm) above the finished floor.
  - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- E. Install guards on thermostats in the following locations:
  - 1. Entrances.
  - 2. Public areas.
  - 3. Where indicated.
- F. Install automatic dampers according to Division 15 Section "Duct Accessories."
- G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- H. Install labels and nameplates to identify control components according to Division 15 Section "Basic Mechanical Materials and Methods."
- I. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."
- J. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."
- K. Install steam and condensate instrument wells, valves, and other accessories according to Division 15 Section "Steam and Condensate Piping."
- L. Install refrigerant instrument wells, valves, and other accessories according to Division 15 Section "Refrigerant Piping."
- M. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.

### 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. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
  - 2. Install exposed cable in raceway.
  - 3. Install concealed cable in raceway.
  - 4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
  - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

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

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
  1. Install piping adjacent to machine to allow service and maintenance.
- B. Ground equipment.
  1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
  1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
  2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
  3. Calibration test electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
- B. Engage a factory-authorized service representative to perform startup service.
- C. Replace damaged or malfunctioning controls and equipment.
  1. Start, test, and adjust control systems.
  2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
  3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
- D. Verify DDC as follows:
  1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
  2. Verify operation of operator workstation.

3. Verify local control units including self-diagnostics.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.
  1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
  2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.
  3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
  4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

### 3.7 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

**END OF SECTION 15900**