7). Boiler management system (ACS) with Combination Control System (CCP).

gg. Additional control system features to include:

1). Ambient temperature system start/stop.
2). Circulator pump delay timer.
3). Auxiliary start delay timer.
4). Auxiliary temperature sensor.
5). Analog output (mA) monitoring of temperature setpoint, supply temperature, or boiler fire rate.
6). Remote interlock circuit.
7). Delayed interlock circuit.
8). Remote alarm fault relay.

6. Electrical Power: 120 VAC/1 PH/60 Hz.

2.2 BOILER MANAGEMENT SYSTEM

A. Manufacturers:

1. Aerco Boiler Control System (ACS).
2. Approved equal.

B. Description: Boiler manufacturer's boiler management system control the integrated operation of the boilers on the project, and to provide a communication gateway to the building automation system. The boiler management system shall control operation and sequencing of multi-boiler central heating system.

C. Operation:

1. Control all operation and energy input of the multiple boiler heating plant.
2. Utilize MODBUS protocol to communicate with the boilers via a RS-485 port.
3. Controller shall have the following capabilities:

a. Vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize condensing capability and thermal efficiency.
b. Maintain boiler header temperature setpoint within 2 degrees F. Control will be PID.
c. Provide contact closure for auxiliary equipment such as pumps and combustion air inlets dampers.
d. Operational modes:

1). Internal setpoint.
2). Outdoor temperature reset control.
3). 4 mA to 20 mA setpoint control.
4). Network temperature setpoint control.

D. Assembly/Fabrication:

1. Other features shall include:

a. UL approved.
b. Microprocessor based PID type control.
c. LCD display monitoring of sensors and interlocks.
d. Non-volatile backup of control setpoints.
e. Automatic rotation of lead boiler to balance operating time.
f. Provision for setback and remote alarm contacts.
g. Adjustable seasonal start/stop ambient temperature.
h. Contact closure control for auxiliary equipment (i.e. circulator pumps).
i. Supply header temperature control utilizing external inputs:

1). Temperature Setpoint (4-20 mA): Boiler outlet temperature setpoint controlled linearly using a 4-20 mA input signal supplied from the building automation system.
2). MODBUS Temperature Setpoint: Boiler outlet temperature setpoint controlled by external communication utilizing MODBUS protocol via a RS-232 port.

2. Open Protocol Interface: When the building automation system does not have MODBUS protocol capability and interoperability is required, provide MODBUS Gateway to act as interface/translator between the BAS and the boiler management system. Supported protocols to include BACNET, LON and N2. Provide protocol interface for the HVAC control system selected for the project.

2.3 EMERGENCY BOILER SHUTOFF

A. Provide an emergency boiler shutoff switch. See Division 26.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Installer: Perform work by experienced personnel previously engaged in boiler plant construction and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

A. Protection of In-Place Conditions: Cover products and plug piping connections to protect equipment from construction dirt and debris.

B. Surface Preparation:

1. Prior to installation of boilers, verify concrete housekeeping pads are complete and properly sized for boiler mounting.
2. Prior to installation of stacks, verify that shop drawings are approved and stack locations and routing have been coordinated with required roof penetrations and the work of other trades.

3.3 INSTALLATION

A. Special Techniques:

1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
2. Install Boiler management system (BMS) in accordance with manufacture's installation instructions. Connect each of the boilers to the BMS. Program BMS to maintain boiler water temperature control as described in Sequence of Operation below.
3. Connect to the building automation system through the open protocol communication port in the BMS.
4. Setting of equipment:

    a. Set equipment on concrete housekeeping pads compatible with the building structural system.
    b. Level equipment to within recommended tolerances.

5. Anchoring:

    a. Anchor boilers to housekeeping pads as recommended by the manufacturer and to allow for normal expansion and contraction.
    b. Coordinate with Section 20 0548 - Vibration and Seismic Control.

6. Thermal Expansion:

    a. Install hydronic piping to allow for normal thermal expansion and contraction.
    b. Provide anchors where necessary and as indicated.
    c. Provide expansion loops, anchors and alignment guides to suit conditions and as indicated.

7. In systems containing glycol, provide only products specifically designed and approved for continuous operation with the glycol solution specified.
8. Install components that were removed from equipment for shipping purposes.
9. Install components that were furnished loose with equipment for field installation.
10. Provide interconnecting electrical control and power wiring.
11. Provide fuel gas vent and service piping.
12. Provide piping for boiler pipe connections.
13. Program, adjust and operationally test boiler operation and sequencing in accordance with the manufacturer's written installation and testing instructions and Section 25 9000 - Sequence of Operations.
14. Touch up marred or scratched factory finished surfaces using finish materials furnished by manufacturer.
15. Install emergency boiler shutoff switch outside the boiler room at each exit at 48 inches above finished floor.

B. Interface with Other Work: Coordinate and sequence installation of boilers and stacks with trades responsible for portions of this and other related sections of the Project Manual.

C. Systems Integration: Coordinate location and operation of boiler emergency shutoff switch(es) with Divisions 26, 27 and 28.

3.4 REPAIR/RESTORATION

A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.

B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 SITE QUALITY CONTROL

A. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

B. Manufacturer Services:

1. Provide manufacturer's representative start-up and instruction of each complete boiler system including all components assembled and furnished by the manufacturer whether or not of his own manufacture.
2. Start-up shall be conducted by experienced and factory authorized technician in the regular employment of the authorized service organization.
3. Start-up and adjust the system to within the tolerances as specified by the equipment manufacturer.
4. Operationally test safety devices and record settings. Test and record oxygen, carbon dioxide, stack temperature, and calculate excess air and steady state efficiency. Make final lead/lag setpoint adjustments. List setpoints in report. Submit final data for review.
5. Test boiler operation and sequencing in accordance with the manufacturer's written installation and testing instructions and Section 25 9000 - Sequence of Operations.
6. Provide a start-up report that includes final control settings, and a performance chart of the control system furnished.
7. Submit a letter of certification with copy of start-up report, indicating that the boiler start-up has been completed, that the boilers are properly adjusted and operating within the tolerances as specified by the manufacturer, and that the sequence of operation is fulfilled.

3.6 ADJUSTING

A. Coordinate and work directly with the requirements of Section 230593 - Testing, Adjusting and Balancing, to provide systems in proper operating order.

B. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.7 CLEANING

A. Waste Management: After construction is completed, clean and wipe down exposed surfaces of boilers and burners.

3.8 CLOSEOUT ACTIVITIES

A. Demonstration: Provide 2 hours of demonstration conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

B. Training: Provide 2 hours of operational instruction conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

END OF SECTION 235216

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Roof top air handling units.
2. Air filter media and support frames.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 230131 - Duct Cleaning
7. 230593 - Testing, Adjusting and Balancing
8. 232113 - Hydronic Piping and Specialties
9. 233100 - Ducts and Accessories
10. 254000 - Variable Speed Drives
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations
13. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. AMCA 99 (Air Movement and Control Association) - Standards Handbook.
3. ASHRAE Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.
4. ASHRAE Standard 52.2-2012 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for the packaged rooftop air handling equipment, which will be distributed to the locations shown.
2. The method of air distribution is specified elsewhere.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.
2. Operate ventilation systems in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide clearly annotated manufacturer's product literature that demonstrates compliance with the specified performance, manufacturing methods, appurtenances and salient features.
2. Provide fully labeled fan curve(s) with system curve and operating point clearly plotted. For variable speed fans, provide fan curves for both minimum and maximum operating points.
3. Provide custom sound power level data (decibels) for each octave band for fan inlet, fan discharge and radiated sound power of the assembled air handling unit as shown. Determine sound level data using one of the following methods:

    a. Actual measurements from tests performed in accordance with AMCA Standards in an AMCA registered test chamber.
    b. Documented calculations that start with AMCA tested fan sound data and are modified in accordance with 2011 ASHRAE HVAC Applications, Chapter 48 - Noise and Vibration Control accurately predict the sound power levels for the configuration shown.

4. Provide electrical connection requirements.
5. Provide electrical power connection and control logic wiring diagrams. Diagrams must differentiate between factory installed and field-installed wiring.

C. Substitutions: Cost of any design modifications as a result of proposed product substitutions shall be borne by the Contractor.

D. Shop Drawings:

1. Provide dimensional and orientation information (plan and elevation) for the approved rooftop air handling unit(s) incorporated into the ventilation system shop drawings.

2. Indicate actual cabinet location, sectional and overall cabinet dimensions, roof curb dimensional requirements, mixing box damper sizes and arrangement, access door locations, access clearances for filter, coil and fan replacement, duct connections, and electrical connection points.
3. Provide detail for filter holding frames, grids and filter housing arrangements as applicable. Indicate filter sizes and number of each filter size necessary to complete each filter bank, Using 24 inch x 24 inch filter dimensions whenever possible.
4. Coordinate roof curb requirements and roof penetration location with Architectural and Structural.
5. Label overall roof top unit(s) as scheduled. Label each cabinet section as specified.
6. Provide cabinet anchoring method approved by the seismic design engineer in accordance with Section 200548 – Mechanical Vibration and Seismic Control.

E. Operation and Maintenance (O&M) Manual:

1. Provide a complete copy of the manufacturer's written installation, operation and maintenance manual to include the following information:

   a. Approved product data submittal information.
   b. Installation instructions.
   c. Operating instructions.
   d. Troubleshooting guide.
   e. Preventative maintenance requirements.
   f. Complete parts list.
   g. Recommended spare parts list.

2. Neatly annotate the O&M manual to clearly indicate information applicable to the equipment installed.

F. Manufacturer Reports:

1. Provide a certificate from the Manufacturer's Representative indicating that the roof top unit(s) is/are installed and operational in accordance with the manufacturer's written installation, operation and maintenance manual.
2. Provide start-up and operational checks using manufacturer checklists, signed by both the installing Contractor and Manufacturer's Representatives.

G. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

A. See section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

B. Extra Stock Materials: Spare Filters. Furnish one complete set of replacement filters for each roof top unit upon final completion of project. Filters are to remain sealed in their original boxes and labeled by equipment tag as scheduled. Locate filters in storage area designated by the Contracting Agency.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

B. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with a minimum of 10 years' documented experience.

C. Certifications: Air filters certified and tested in accordance with ASHRAE Standard 52.2.

D. Regulatory requirements: Products requiring electrical connection shall be listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the Authority Having Jurisdiction.

1.9 DELIVERY, STORAGE, AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

B. Storage and Handling Requirements: Maintain access doors shut, dampers and supply duct connections covered, and drain connections capped to protect components from construction dirt and debris.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Trane.

B. Daikin-McQuay.

C. Approved equal.

2.2 ROOFTOP AIR HANDLING UNITS (RTU-1)

A. Dimensions:

1. Overall roof top unit dimensions scheduled are for the basis of design air handler manufacturer as indicated.
2. The dimensions for “as equal” manufacturers may differ.

B. Unit Casing Construction:

1. Heavy gauge steel cabinet, reinforced, and braced with steel angle framing for maximum rigidity. Designed for outdoor use and roof curb mounting. Unit base shall be watertight.
2. Exterior panels shall be zinc-coated, galvanized steel painted with gray air-dry finish.
3. Unit shall be double-wall construction in the air handling section with insulation. Interior insulation subject to the airstream shall be lined.
4. Acoustically lined cabinet interior with 2-inch thick UL listed acoustical liner materials.
5. Exterior casing, base frame and accessories coated with baked enamel finish.
6. Internal components and accessories coated with baked enamel finish or galvanized.
7. Connect parts with plated, galvanized steel fasteners.
8. Provide interior liner type and drain pan as indicated under each air handler section.
9. Provide steel stamped nameplate with air handler performance date clearly indicated.

C. Weather Hood: Galvanized steel construction with intake mounted bird screen painted to match cabinet.

D. Mixing Box Section:

1. Twenty gauge solid galvanized steel interior liner.
2. Hinged, insulated, double walled access door.
3. Interior lighting with wall switch for maintenance and general cleaning.
4. Sloped, galvanized steel drip pan with capped drain plug and drain hose adapter.
5. Outside Air Damper:

    a. Manufacturer: Tamco, Series 9000 or pre-approved equal.
    b. Low leakage, heavy gauge, internally insulated, extruded aluminum, air foil blades with extruded EDPM blade gaskets and frame seals.
    c. Galvanized steel frame with parallel blade action.
    d. Damper Sizing: Size outside air damper for maximum RTU air flow rate (CFM) scheduled using a flow velocity of 1,000 FPM not to exceed 0.1-inch static pressure drop with damper fully open.

6. Return Air Damper:

    a. Manufacturer: Ruskin, Model CD50 or pre-approved equal.
    b. Low leakage, heavy gauge, extruded aluminum, parallel arrangement, air foil blades with vinyl edge seals.
    c. Galvanized steel frame with parallel blade action.
    d. Damper Sizing: Size return air damper for maximum RTU air flow rate (CFM) scheduled using a flow velocity of 1,000 FPM not to exceed 0.1-inch static pressure drop with damper fully open.

7. Damper Arrangement:

    a. Provide dampers, factory installed and sealed to the mixing box as indicated.
    b. Provide outside air intake damper horizontally centered to front of mixing box

c. Provide return air damper horizontally centered on base of mixing box.

E. Filter Section:

1. Twenty gauge solid galvanized steel interior liner.
2. Two sets of pre-filters for summer/winter arrangement with preheat coil.
3. Provide factory installed filter frames by the roof top unit by manufacturer with closed cell synthetic rubber and positive spring type clamps to hold filter elements securely against gaskets.
4. Provide access for changing filters from one or both sides of housing.
5. Filters:

   a. Provide disposable, pleated dry media filters having a Minimum Efficiency Reporting Value of MERV 8 for prefilters, and MERV 14 for final filters when tested in accordance with ASHRAE 52.2.
   b. 2-inch filter depth for prefilters, 12-inch filter depth for final filters.
   c. Complete filter shall be UL listed as a Class 2 air filter.
   d. Filter shall be constructed from pleated media supported and bonded to welded wire grid within a rigid beverage board frame. Media shall be non-woven, reinforced cotton and synthetic fabric. Media shall provide not less than 4.6 square feet of filter area for each square foot of face area. Media and frame shall be bonded to prevent air leakage.
   e. Design of filter bank shall be based on an airflow rate of not more than 350 CFM per square foot of gross face area unless otherwise indicated. Initial static pressure loss shall not exceed 0.08 inches water column at 250 feet per minute face velocity. Filter shall be designed to operate at up to 0.9 inch water column, if required.
   f. Preferred filter sizes are 24 by 24 by 2 inches with maximum of one 24 by 12 by 2 inches per row. Filter banks shall be designed to use the minimum number of readily available standard filter sizes.
   g. Manufacturers: Farr 30/30 (Basis of Design), American Air Filter, or approved equal.

6. Filter Gauges:

   a. Provide a dial type gauge with diaphragm magnetically coupled to pointer and with connections to upstream and downstream static pressure probes for each filter bank.
   b. Provide monitoring contacts for connection to the BAS. Coordinate with 255000 - Building Automation System and Section 25 9000 - Sequence of Operations to connect filter monitoring pressure switches to same probes as the gauge.
   c. Gauge scale range shall be 0 to 1 inch water column.
   d. Manufacturers: Magna-helic (Basis of Design) or approved equal.

F. Refrigeration System:

1. Compressor:

   a. Industrial grade, energy efficient direct drive speed scroll type.
   b. Motor shall be suction gas cooled hermetic design.
   c. Include centrifugal oil pump with dirt separator, oil sight glass, and oil charging valve.

2. Evaporator Coil:

a. Heavy duty aluminum fins mechanically bonded to copper tubes.
b. Provide thermostatic expansion valve for each refrigerant circuit.
c. Positive pitched galvanized drain pan.

3. Air Cooled Condenser Section:

a. Coil shall have aluminum microchannel coils.
b. Vertical discharge, direct drive fan.
c. Factory installed electronic low ambient option to allow for operation down to 0 degrees F.
d. Factory-installed louvered steel guards around perimeter of condensing section.

G. Preheat and Heating Coil Sections:

1. Cabinet:

a. Twenty gauge solid galvanized steel interior liner with sloped drip pan and capped drain plug with hose adapter.
b. Sloped, galvanized steel drip pan with capped drain plug and drain hose adapter.
c. Provide split casing panel to facilitate coil removal. Coordinate panel location with coil access and coil piping.

2. Preheat and Heating Coil:
a. Factory assembled and installed, non-freeze Type 5W AHRI Certified coil, with hot water modulating valve and actuator. Coil construction shall allow for complete drainage.
b. Provide heating coil section with adequate interior space for terminal hydronic heating piping and components as shown.
c. Provide coil with scheduled operational performance characteristics.
d. Coils designed for counter-flow heat transfer with equal pressure drop through each circuit.
e. Working Pressure: 250 PSIG.
f. Primary surface:

1). Round, seamless, 0.020 inch thick copper tubing.
2). Tubes mechanically expanded into fins over the entire finned length.
3). Brazed joints.

g. Secondary surface:

1). Solid aluminum fins (no punched openings to accumulate lint and dirt) with full drawn collars (Bare copper tube not visible between fins).
2). Fin thickness: 0.0075 inches.

h. Coil Casing: Continuous 16 gauge galvanized steel with reinforced flange type side plates.
i. Coil Headers:

1). Seamless, copper tubing.

2). Low point coil drain and high point coil vent.

H. Fan Section:

1. Cabinet:

a. Twenty gauge perforated, galvanized steel interior liner.
b. Hinged, insulated, double walled access door.
c. Interior lighting with wall switch for maintenance and general cleaning.
d. Sloped, galvanized steel drip pan with capped drain plug and drain hose adapter.

2. Fan Manufacturers:

a. Greenheck.
b. Cook.
c. Barry Blower.
d. Twin City.

3. General Fan Requirements:

a. Provide factory assembled, balanced and tested fan unit of the size, type and capacity scheduled. AMCA listed and labeled.
b. Provide factory applied enamel coating system to fan assembly components (except aluminum).
c. Provide fan arrangement with accessibility for complete cleaning, component replacement and preventative maintenance. Provide grease fitting(s) with extended grease lines (as necessary for direct access).

4. Vibration Isolation:

a. Isolate fan frame from unit casing using stable spring vibration isolators with a seismic snubbers.
b. Bearings: Greater than 200,000 hours average rated life at rated load and speed specified.

5. Fan Drives:

a. Provide v-belt drive for each fan selected for not less than 1.5 times the motor nameplate horsepower. Light duty belts (FHP) acceptable only with motors less than one (1)-horsepower. Sheaves shall be cast iron or steel.
b. Provide fixed speed drive sheave. Change fan and drive sheave in the field as necessary to attain required fan performance.
c. Provide OSHA belt guard with hinged tachometer cap.

6. Motors: See Section 200513 – Common Motor Requirements, for detailed fan motor specifications.
7. Sound data:

a. Factory test fan assemblies to determine suction, discharge and radiated sound levels (decibels) for each octave band in accordance with AMCA Standards. Include sound level data with fan submittals.

b. When sound ratings are not specified, physical characteristics including type, wheel diameter and fan speed shall be the basis of comparison with specified requirements.
c. Octave band sound power levels shall not exceed those scheduled.

I. Electrical:

1. Factory pre-wired for single point connection.
2. Auxiliary fan motor starter contact.
3. High voltage control panel shall have door handle disconnect switch.
4. Unit mounted 115 volt convenience outlet.

2.3 BUILDING AUTOMATION SYSTEM CONTROLS

A. Provide roof top unit controls in accordance with Section 255000 - Building Automation System to include temperature and pressure sensors, damper actuators, controllers, and interface panels to control the roof top unit in accordance with Section 259000 -Sequence of Operations.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Installer: Perform work by experienced personnel previously engaged in ventilation system construction and air handling unit installation, and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

A. Protection:

1. Maintain access doors shut, air handler box dampers and supply duct connections covered and drain connections capped to protect components from construction dirt and debris.
2. Provide a complete set of pre-filters for use during construction. Final filter bank media is to remain sealed in original boxes until final building housekeeping has been completed.
3. Protect return air inlet with 30 percent filters during construction.

3.3 EXAMINATION

A. Verify that roof curb is installed, level and of the correct dimensions to accept and support the weight of the roof top unit.

B. Verify that the roof curb’s interior footprint has been pre-insulated with vapor barrier to match the adjacent roof R-value.

C. Verify power supply is roughed in, located, and sized properly for the unit’s single point power connection.

D. Verify that hydronic piping penetrations have been installed, sleeved water-tight and are aligned with the heating coil section coil piping chase locations. Piping shall penetrate up through bottom of unit at pipe chase locations.

3.4 INSTALLATION

A. Install rooftop air handling units and components in compliance with the manufacturer's written installation instructions and the following:

1. Install BAS actuators, sensors, controls and control wiring in accordance with Section 25 5000 - Building Automation System.
2. Install electrical power and wiring in accordance with Divisions 26, 27 and 28.

3.5 CONSTRUCTION

A. Interface with other Work:

1. Coordinate and sequence installation of each component with trades responsible for portions of this and other related sections of the Project Manual.
2. Rework required, as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work, shall be completed at no additional expense to the Owner.

3.6 REPAIR/RESTORATION

A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.

B. Substitute replacement parts from other manufacturers are not acceptable.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Verify roof top unit(s) is/are installed and operational in accordance with the manufacturer's written installation instructions.
2. Both the Contractor and Manufacturer's Representative(s) shall sign start-up and operational checklist to confirm proper system installation and operation.

B. Site testing, conducted with ventilation system operating at maximum air volume flow rate with clean filter media installed:

1. Verify each filter bank is properly sealed and filter bank leakage is within manufacturer's performance tolerances.
2. Verify that filter bank differential pressure gauges are operating properly in accordance with manufacturer's written installation, operation and maintenance instructions.

3. Verify that clean filter differential pressures are as indicated in manufacturer's submittal data (within 5 percent) for actual filter bank flow velocity.

3.8 CLEANING

A. Upon completion of installation and prior to initial start-up, vacuum clean internal and external surfaces.

B. Upon completion of final housekeeping and with written approval of the Contracting Agency, replace construction filters with a complete set of new filters for use during testing and balancing.

3.9 SYSTEM START-UP

A. Start-up and operate roof top units in accordance with the manufacturer's written installation, operation and maintenance (IO&M) manual.

B. Verify proper operation of sequences in accordance with Section 259000 - Sequence of Operations.

C. Document start-up and operational checks using manufacturer and PC/FC checklists and submit in accordance with submittal requirements.

3.10 ADJUSTING

A. Test, adjust and balance roof top air handling equipment in accordance with Section 23 0593 - Testing, Adjusting and Balancing, the manufacturer's recommendations, and as otherwise directed by the Contracting Agency.

END OF SECTION 237416

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Packaged, direct expansion, air conditioning systems with microprocessor based controls for electrical room cooling.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200548 - Mechanical Vibration and Seismic Control
4. 221300 - Sanitary Waste and Vent Piping and Specialties
5. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. ARI 360 - Commercial and Industrial Unitary Air Conditioning Equipment testing and rating standard.
3. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
4. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment.
5. ANSI/UL 465 - Central Cooling Air Conditioners Standard for Safety Requirements.

1.3 SYSTEM DESCRIPTION

A. Design Requirements: This section describes specific requirements, products and methods of execution for the dedicated air conditioning units.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.
2. Operate system in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data: Submit copies of product data indicating rated capacities, weights, accessories, and electrical requirements.

C. Shop Drawings: Submit drawings indicating components, dimensions, weights and loadings, required clearances, and location, routing and size of refrigerant lines and condenser discharge ductwork.

D. Closeout Submittals: Submit copies of operation and maintenance manuals in accordance with Section 20 0000 - Mechanical General Requirements.

E. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

B. Regulatory Requirements: Units shall be UL listed.

1.9 DELIVERY, STORAGE AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 SELF-CONTAINED AIR CONDITIONING UNIT (AC-1/CU-1, AC-2/CU-2)

A. General:

1. Provide packaged, direct expansion, self-contained air conditioning systems as scheduled. System consists of ceiling wall mounted evaporator unit with a variable speed inverter driven compressor and fan motor and a separate, remote, mounted condenser unit. System refrigerant shall be R-410A. The system shall maintain zone setpoint temperatures using a packaged wall mounted controller.
2. Basis of Design: Mitsubishi P Series.

B. Indoor Unit:

1. The indoor unit shall be factory assembled and tested complete with factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
2. Indoor unit and refrigerant pipes shall be charged with dehydrated air prior to shipment from the factory.
3. Cabinet:

    a. The cabinet shall be fixed to factory supplied wall hanging brackets.
    b. Multi-directional refrigerant and drain piping offering four (4) directions for refrigerant piping and two (2) directions for draining are required.

4. Fans and Motors:

    a. The fan shall be direct-drive fan type with statically and dynamically balanced impeller with high and low fan speeds available.
    b. The fan motor shall operate on voltage as scheduled on the drawings.
    c. The fan motor shall be thermally protected.

5. Filter: Filter return air by means of an easily removable, washable filter.
6. Evaporator Coil:

    a. Coils shall be of nonferrous construction with smooth plate fins on copper tubing. Tubing shall have inner grooves for high efficiency heat transfer. Tube joints shall be brazed with phos-copper or silver alloy.
    b. The coil shall be pressure tested at the factory.

7. Electrical:

    a. The fan motor shall operate on voltage as scheduled on the drawings.
    b. 208-230 volts, 1 phase, 60 hertz. System shall be capable of satisfactory operation within voltage limits of 198 to 253 volts. Power to the unit shall be supplied from the outdoor unit, using the Mitsubishi Electric A-Control system. For A-Control, a

three (3) conductor AWG-14/16 wire with ground shall provide power feed and be-directional control transmission between the outdoor and indoor units.

C. Remote Condensing Unit:

1. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a swing compressor, motors, fan, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, service ports and suction accumulator.

2. The outdoor unit shall be equipped with front, rear, and side advanced wind baffles.
3. The system will automatically restart operation after a power failure and will not cause any settings to be lost, eliminating the need for re-programming.
4. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
5. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
6. Fans and Motors:

   a. The condensing unit fan shall consist of one propeller type, direct-drive fan motor that has multiple speed operation via a DC (digitally commutating) inverter.
   b. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
   c. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

7. Condenser Coil:

   a. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.

8. Compressor:

   a. The compressor for models PUZ(Y)-A12/18/24/30/36/42NH/KA7 shall be a DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology.
   b. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.
   c. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
   d. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.

D. Quality Assurance:

1. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), and bear the ETL label.
2. Wiring shall be in accordance with the National Electric Code (NEC).
3. System rated in accordance with Air Conditioning Refrigeration Institute's (ARI) Standard 210/240 and bear the ARI label.
4. Provide a holding charge of dry nitrogen in the evaporator.
5. System efficiency meets or exceeds 17.6 SEER.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Install units in accordance with manufacturer's written installation instructions.
2. Install units plumb and level, firmly anchored in the locations indicated while maintaining manufacturer's recommended clearances.
3. Adjust evaporator unit location to align with ceiling grid.

B. Electrical Wiring: Furnish one copy of manufacturer's electrical connection diagrams to the electrical subcontractor.

C. Piping Connections: Furnish one copy of manufacturer's condensate pump connection diagram to the plumbing subcontractor.

3.2 FIELD QUALITY CONTROL

A. Startup air conditioning unit in accordance with the manufacturer's written start up instructions.

B. Test control features and demonstrate compliance with operational requirements.

END OF SECTION 238123

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Unit heaters.
2. Radiant ceiling panels.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 200700 - Mechanical Insulation
7. 204100 - Mechanical Demolition
8. 230593 - Testing, Adjusting and Balancing
9. 232113 - Hydronic Piping and Specialties
10. 233100 - Ducts and Accessories
11. 233600 - Air Terminal Units
12. 233700 - Air Outlets and Inlets
13. 253000 - Building Automation System Field Devices
14. 255000 - Building Automation System
15. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards: See Section 200000 - Mechanical General Requirements.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements: Provide terminal heating and cooling units, piping, appurtenances, and controls to automatically maintain interior temperature setpoint for each area of the building.

B. Performance Requirements: Provide performance and output shown or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Submit product literature for items specified in Part 2 and those products required by the performance standards of this section. Literature clearly annotated to indicate specified salient features and performance criteria.
2. Include the following:

a. Performance characteristics as scheduled.
b. Enclosure style, material and grille arrangement.
c. Dimensional data.

C. Shop Drawings:

1. For custom architectural fintube heating enclosures, provide shop drawings which include:

a. Custom enclosure dimensions and method of construction.
b. Fintube location and support method to include expansion/contraction compensation.
c. Inlet and outlet grille model and fastening method.

2. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
3. Indicate mechanical and electrical service locations and requirements.

D. Samples:

1. Provide color samples of fintube and cabinet unit heater enclosures.
2. Colors to be selected by the Contracting Agency.

E. Provide certificates, manufacturer’s instructions, and manufacturer’s field reports for Quality Assurance/Control Submittals:

1. Provide a complete manufacturer’s written installation, operation and maintenance manual for each type of installed equipment.
2. Clearly annotate the manual to indicate applicable information for the specific equipment model(s) installed.
3. Included with the manual one copy of the completed start-up and operation checklist. The checklist shall include:

a. Printed names and signatures of the installers.
b. Documentation from Manufacturer's representative and Contracting Agency that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.

F. Closeout Submittals:

1. Project Record Documents: Record actual locations of components and locations of access doors in terminal unit cabinets required for access or valves.
2. Operation and Maintenance (IO&M) Manuals:

a. Refer to Section 200000 - Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
b. Provide copies of approved submittal information for inclusion within the project IO&M Manual. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, parts listings, and spare parts list.

G. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

B. Extra Stock Materials: Provide one set replacement filters for cabinet unit heaters and fan coil units.

1.8 QUALITY ASSURANCE

A. See Section 200000 - Mechanical General Requirements.

B. Regulatory requirements: Products requiring electrical connection shall be listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the Authority Having Jurisdiction.

1.9 DELIVERY, STORAGE, AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

B. Provide 5-year manufacturer's warranty for unit heaters and cabinet unit heaters.

PART 2 - PRODUCTS

2.1 UNIT HEATERS

A. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.

B. Casing: 0.0478-inch steel with threaded pipe connections for hanger rods.

C. Finish: Factory applied baked enamel finish.

D. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.

E. Air Outlet: Adjustable pattern diffuser on projection models and two way louvers on horizontal throw models.

F. Motor: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models. Refer to Section 200513 - Common Motor Requirements.

G. Control: Local disconnect switch.

H. Capacity: As scheduled.

I. Electrical Characteristics:

1. Horsepower, voltage, and phase as scheduled on the Drawings, 60 Hz.
2. Refer to Divisions 26, 27 and 28.

J. Manufacturers: Sterling, Modine, Rittling, Trane, Vulcan, JAGA.

2.2 HYDRONIC RADIANT CEILING PANELS

A. Panel shall consist of extruded aluminum with copper tubing of 0.50 inch ID mechanically attached to the aluminum faceplate. Hold copper tubing in place with an integral aluminum saddle or similar metal fastener which positively secures the tube to the panel. Use of adhesives or clips is not acceptable.

B. Not all panel hardware, mounting and attachment components and features are detailed on the Mechanical and Architectural Drawings. Provide backing, supports, moldings, hangers, cross tees, seismic restraints, hardware, and other appurtenances required for a complete and properly operating finished system. Mechanical fasteners shall not be exposed in the finish work.

C. In addition to the Mechanical Drawings, refer to Architectural reflected ceiling plans and room finish schedule to determine other panel requirements.

D. Provide finish and color selected by the Contracting Agency.

E. Cross brace entire assembly with structural members and insulate with 1-inch thick fiberglass insulation. Configure panels within T-bar ceiling module and run wall to wall.

F. Heating Capacity: Panel total output rating shall be not less than 250 Btuh/SF at 190 degrees F when tested against an average unheated surface temperature (AUST) of 70 degrees F. Data shall be certified by qualified independent test lab.

G. Manufacturers: Airtex, Sterling, or Aero Tech AX.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection: Cover equipment and plug piping connections to protect components from construction dirt and debris.

B. Preparation: Prior to installation of terminal units, make sure wall construction is complete enough to correctly locate and mount units.

3.2 INSTALLATION

A. Install terminal equipment in accordance with manufacturer’s instructions.

B. Install equipment exposed to finished areas after walls and ceilings are finished and painted.

C. Unit Heaters: Hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

D. Hydronic Units:

1. Provide accessible ball type isolation valves on supply and return lines to each terminal unit to allow for unit drain down and repair.
2. Provide low-point drain valve that allows for complete gravity draining of terminal unit.
3. Provide balancing valve as specified elsewhere.
4. Provide high-point automatic air vent as specified elsewhere.

E. Radiant Panels:

1. Provide each panel circuit with shutoff valve on supply and balancing valve on return piping.
2. Install in accordance with the manufacturer's shop drawings.
3. Coordinate with ceiling system and other related work.
4. Mechanical fastenings shall not be exposed in the finished work.
5. Install suspension system in accordance with ASTM C636.
6. Completely cover panel with minimum of 2 inches of fibrous glass, unfaced blanket insulation.
7. Do not connect to supply and return system until system has been flushed and cleaned.

F. Access Doors: Install such that a drain hose may be easily connected to each drain line hose bibb, allowing the applicable portion of the system to be completely drained.

G. Install balancing valves and serviceable products for heating terminal units to be operable and adjustable without removal of the finish cover.

H. Provide pressure and temperature test plugs on both sides of heat transfer elements to measure the drop across runs of heat transfer elements.

I. In systems containing glycol, provide only products specifically designed and approved for continuous operation with the glycol solution specified.

3.3 CONSTRUCTION

A. Interface with Other Work:

1. Coordinate and sequence installation of terminal heating and cooling units with trades responsible for portions of this and other related sections of the Project Manual.
2. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.4 REPAIR/RESTORATION

A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.

B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Verify units are installed and operational in accordance with the manufacturer's written installation instructions.
2. Both the Contractor and Manufacturer's Representatives shall sign start-up and operational checklist to confirm proper unit installation and operation.

3.6 ADJUSTING

A. Adjust functional components for proper operation in accordance with manufacturer's recommendations, or as otherwise directed.

B. Coordinate and work directly with the Testing, Adjusting and Balancing Agency to provide systems in proper operating order. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.7 CLEANING

A. After construction is completed (including painting), and prior to initial start-up, clean and wipe down exposed surfaces of units. Vacuum clean coils and inside of cabinets and enclosures.

B. Touch up marred or scratched surfaces of factory finished cabinets and enclosures, using finish materials furnished by manufacturer.

C. Clean permanent filters or install new disposable filters.

3.8 DEMONSTRATION AND START-UP

A. Start-up and operate terminal heating and cooling units in accordance with the manufacturer’s written installation and operation manual check list.

B. Demonstrate proper system operation using the building automation system.

C. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.

END OF SECTION 238200

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements, products, procedures, performance requirements, and methods of execution relating to the Building Automation System (BAS) terminal devices and field hardware.
2. Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.

B. Related Sections: Refer to Section 255000 - Building Automation System

1.2 REFERENCES

A. Refer to Section 255000 - Building Automation System.

1.3 SYSTEM DESCRIPTION

A. Refer to Section 255000 - Building Automation System.

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 255000 - Building Automation System.

1.5 SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.6 CLOSEOUT SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. Refer to Section 255000 - Building Automation System.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 255000 - Building Automation System.

1.10 WARRANTY

A. Refer to Section 255000 - Building Automation System.

PART 2 - PRODUCTS

2.1 TEMPERATURE SENSOR

A. Digital room sensors:

1. Temperature monitoring range: 55/95 degrees F.
2. Network jack.
3. Output signal: Changing resistance.
4. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
5. Wall Mounted unit with finished cover:

a. Private offices and rooms:

1). LCD display, day/night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.
2). Set Point and Display Range: 55 degrees to 95 degrees F.

b. Public Spaces: Blank Cover.

B. Duct (single point) temperature:

1. Temperature monitoring range: 20/120 degrees F.
2. Output signal: Changing resistance.
3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
4. Sensing element shall be located a minimum of 25 percent across duct width.

C. Duct Average temperature:

1. Temperature monitoring range: 20/120 degrees F.
2. Output signal: 4-20 mA DC.
3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
4. Sensor Probe Length: 25 feet.

2.2 WALL MOUNTED SENSOR GUARD

A. Heavy-duty wire cage type with mounting plate.

B. Cast Aluminum Guard and mounting bracket.

C. Clear or opaque butyrate plastic guard, key lock, mounting plate.

2.3 MEDICAL GAS ROOM HYDRONIC UNIT HEATER THERMOSTAT AND ROOM TEMPERATURE MONITORING

A. Unit Heater Thermostat: Amperage capacity sufficient to cycle fan without need for contactor.

B. Provide a blank face BAS temperature sensor for monitoring of medical gas room temperatures.

2.4 BOILER ROOM HYDRONIC UNIT HEATER THERMOSTAT

A. Unit Heater Thermostat: Amperage capacity sufficient to cycle fan without need for contactor.

2.5 DIGITAL STATUS POINTS

A. Digital status shall be monitored by sensing normally closed contacts (contact closed in alarm conditions). The addition of the monitoring relay shall not affect the operation of the systems involved.

2.6 DIGITAL COMMAND POINTS

A. Command relays shall be momentary, automatic, maintained, or magnetic latch fail/safe as required. Maintained contacts located in occupied spaces or plenum spaces shall be mechanically latched. Relays shall be plug in and field replaceable. Contact ratings shall be in accordance with service.

2.7 CURRENT SENSOR

A. Provide current sensors that convert AC current to a proportional (4-20 mA) DC current.

B. Provide reverse voltage and high over current capacity.

C. Provide red LED light to indicated relay status and power.

D. Temperature operating range: 5 to 140 degrees F.

E. Provide UL Listed device.

2.8 CURRENT SENSING RELAY

A. Provide solid-state, self-calibrating, current operated relay suitable for equipment status monitoring. Provide a relay that changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.

B. Provide red LED light to indicated relay activation.

C. Temperature operating range: minus 30 to 140 degrees F.

D. Provide UL Listed device that is rated for plenum installation.

2.9 RELAYS

A. Applications: Relays external to the controls shall include (but not be limited to) the following:

1. Control relays for start/stop or open/close control of equipment.
2. Monitoring relays for electrical circuit on/off or open/closed status detection.
3. Interposing relays to provide interface between solid state circuitry and ac-driven control relays.

B. Requirements: Relays shall be housed in dust-tight cases conveniently located for wiring and inspection:

1. Control Relay: Control relays shall be suitable for continuous operation of 120 VAC and be able to interrupt the control circuits of various HVAC equipment. The number of contacts required for the relay shall be determined from the number of independent equipment to be controlled. The number of control relays required for the motor start/stop circuit shall be determined from examination of the equipment to be controlled.
2. Monitoring Relay: Monitoring relays shall be suitable for continuous operation at the voltages of the circuits to be monitored. The monitoring relays shall be connected in such a way that the operation of the relay contact shall represent the change of status of the monitored circuit (i.e. ON/OFF, etc.) or duplicate the operation of the existing alarm circuit (i.e. high/low, etc.). The addition of the monitoring relay shall not affect the operation of the systems involved.
3. Interposing Relay: Interposing relays shall be DC driven and be utilized to provide interface between solid state circuitry and ac-driven control relays as required.

2.10 CONTROL VALVE

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

B. Globe Valve 2 inch and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and sweat ends.

C. Globe Valve 2-1/2 inch and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

D. Hydronic system globe valve shall have the following characteristics:

1. Rating: ANSI Class 125 for service at 125 PSIG and 32/250 degrees F operating conditions.
2. Internal Construction:

    a. Replaceable plugs and seats of stainless steel or brass.
    b. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
    c. 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.
5. Select heating valves shall fail to a Normally Open to heat position, unless otherwise indicated. Select cooling valves to normally closed to cooling position.
6. Three-way valves: Mixing type, unless otherwise indicated.

2.11 CONTROL DAMPER

A. Rectangular:

1. Frame: Five inches by one inch by minimum 0.125 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
2. Blades: Provide airfoil-shaped, single-piece blades made of heavy-duty 6063-T5 extruded aluminum. Maximum six inch blade width.
3. Bearings: Molded synthetic sleeve, turning in hole in frame.
4. Seals:

    a. Blade: Extruded vinyl type for ultra-low leakage from minus 50 degrees F. to 350 degrees F. Mechanically attached to blade edge.
    b. Jamb: Flexible metal compression type.

5. Linkage: Concealed in frame.
6. Axles: Minimum 1/2-inch diameter plated steel, hex-shaped, mechanically attached to blade.
7. Finish: Mill aluminum.
8. Performance Data:

    a. Temperature Rating: Withstand minus 50 degrees F. to 350 degrees F.
    b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions:

        1). Closed Position: Maximum pressure of 13 inches W.C. at a 12-inch blade length.
        2). Open Position: Maximum air velocity of 6,000 feet per minute.

c. Leakage: Maximum 2.0 cubic feet per minute per square foot at 1.0 W.C. for sizes 24 inches wide and above.
d. Pressure Drop: Maximum 0.03 inch W.C. at 1,500 feet per minute across 24 inch by 24 inch damper.

9. Manufacturer: Ruskin CD50, Louvers and Dampers, Air Balance, Pottorff, or equal.

B. Round:

1. Frame:

a. Under 6 inches Diameter: 2 inches by 1/2 inch minimum 12 gage galvanized steel tube.
b. 6 thru 12 inches Diameter: 2 inches by 1/2 inch by minimum 14 gage galvanized steel channel.
c. Above 12 thru 24 inches Diameter: 2 inches by 1/2 inch by minimum 1/8 inch galvanized steel channel.
d. Above 24 inches Diameter: 2 inches by 1 inch by minimum 3/16 inch galvanized steel channel.

2. Blade: Provide single-piece construction made of the following material:

a. 18 inches diameter and smaller: Minimum 12 gage galvanized steel.
b. Over 18 inches diameter: Minimum 10 gage galvanized steel, stiffeners as required.

3. Blade Seals: Closed cell polyethylene foam rubber fully encompassing and mechanically attached to blade edge.
4. Bearings: Self-lubricating stainless steel sleeve.
5. Axles:

a. 22 inches Diameter and smaller: Minimum 1/2 inch diameter, full length, plated steel, mechanically attached to blade.
b. Over 22 inches Diameter: Minimum 3/4 inch diameter, full length, plated steel, mechanically attached to blade.

6. Finish: Mill.
7. Performance Data.

a. Temperature Rating: Withstand maximum 250 degrees F.
b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.

1). Closed Position: Maximum pressure of 10 inches W.C.
2). Open Position: Maximum air velocity of 4,000 feet per minute /min.

c. Leakage: Maximum 10 cubic feet per minute total at 1 inch W.C.
d. Pressure Drop: Maximum 0.05 inch W.C. at air volume of 7,000 cubic feet per minute through 24 inch diameter damper.

8. Manufacturer: Ruskin CDR25, Louvers and Dampers, Air Balance, Pottorff, or equal.

2.12 VALVE AND DAMPER ACTUATORS

A. General:

1. Provide electronic direct-coupled actuation for control valves and dampers.
2. Proportional actuators shall accept a 0-10 VDC or 0-20 mA control input and provide a 2-10 VDC or 4-20 mA operating range. Damper actuators and control valve actuators serving valves larger than 3/4" shall provide a 2-10 VDC position feedback signal. The feedback signal shall be independent of the input signal.
3. Actuators indicated by Normally Closed or Normally Open designation on drawings or in sequence of operation shall be spring return type.
4. The actuator shall have electronic overload circuitry to prevent damage to the actuator.
5. Provide actuators listed by Underwriters Laboratories Standard 873 Standard for Safety Temperature-Indicating and -Regulating Equipment.

B. Damper Actuator:

1. Provide damper actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage.
2. Spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
3. Non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
4. Provide actuators in sufficient size, quantity and type to match application. Provide a minimum of one damper actuator for each 24 square feet of damper area. Damper areas shall not exceed manufacturer's ratings.
5. Outside air and return air dampers on mixing boxes shall be linked such that one opens while the other closes. It shall not be possible to close both dampers simultaneously.
6. Dampers: Size for minimum 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. of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
    e. Dampers with 2 to 3 Inches WC 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 WC of Pressure Drop or Face Velocities of 2500 to 3000 FPM: Multiply the minimum full-stroke cycles above by 2.0.
    g. Values noted above do not include normally open or normally closed open spring return dampers. Provide additional torque as required.

7. Size operators with ample power to overcome friction of damper linkage and air pressure acting on the damper blades.

C. Valve Actuator:

1. Provide actuators with enough torque and force required for proper valve close-off against the system pressure.

2. The valve actuator shall be sized based on valve manufacturer's recommendations for flow and pressure differential.

D. Actuators shall be of the following types, unless noted otherwise on the drawings or in the sequences of operation:

Service	Type (1)
Exhaust Air Damper	NC
Air handler/MUA units with outside air:	
Heating Coil valves	NO
Cooling Coil Valves	NC
Air Terminal Units Heating Coil Valves	Floating
Reheat Coil Valves	Floating
Glycol Loop Control valve	NO
Heating Zone Temperature Control Valve	NO
Fan Coil Units	NO

(1) NC = Normally closed. NO = Normally open

2.13 INSTRUMENT ENCLOSURE

A. Steel construction with hinged and lockable doors.

B. NEMA 12 construction only in areas where panels are subject to moisture damage.

C. Wiring connections including I/O and power shall be extended to a numbered, color-coded, and labeled terminal strip for ease of maintenance and expansion.

D. Provide labeling and color coding for wiring. Wiring shall follow a common format typical for the entire facility. Terminal strip color coding and numbering shall follow a common format. Wiring shall be neatly installed in plastic trays or tie-wrapped.

E. Line voltage wiring shall be segregated from I/O wiring and shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

F. Provide a convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers. Provide convenience receptacle for enclosures containing equipment that can be configured or adjusted with a portable computer.

2.14 POWER SUPPLY

A. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75 percent of the rated capacity of the power supply.

B. Input: 120 VAC plus 10 percent, 60Hz.

C. Output: 24 VDC.

D. Line Regulation: Plus 0.05 percent for 10 percent line change.

E. Load Regulation: Plus 0.05 percent for 50 percent load change.

F. Provide an appropriately sized fuse and fuse block shall be provided and located next to the power supply.

G. Provide a power disconnect switch shall be provided next to the power supply.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:

1. Wiring:

a. The HVAC Control Contractor shall provide conduit, wiring, accessories, and wiring connections required for the installation of the control system, as herein specified, unless specifically shown in Divisions 26, 27 and 28.
b. Conduit and wiring shall comply with the requirements of applicable portions of Divisions 26, 27 and 28 and local and national electric codes, unless specified otherwise in this section.
c. System input wiring shall be twisted shielded pair, minimum 20 gauge wire. System analog output wiring shall be twisted shielded pair/3-wire as required, minimum 20 gauge wire. Preconfigured cables between Terminal Unit Controllers and Thermostats are acceptable, minimum 24 gauge.
d. Internal panel device wiring for binary outputs and pilot relay shall be minimum 16 gauge wire.
e. Provide separate conduit for control system power wiring including but not limited to 120 VAC and greater. I/O sensor wiring and data communication cabling shall be segregated from 120 VAC control system power wiring.
f. Wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size 3/4 inch. One half inch conduit may be used for thermostats and valve stub-ups where conduit contains only a single pair.

2. Temperature Sensors:

a. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
b. Outdoor installations shall be of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.

c. Wall Mounted Sensor and Thermostats:

1). Install wall mounted room sensors at a height of 44 inches above finish floor level.
2). Locate sensors as shown on the Drawings.
3). Provide insulated base for sensors mounted on sheet metal, steel columns or exterior walls. Wire penetrations shall be caulked airtight to prevent thermal convection.
4). Provide heavy-duty guards for sensors and thermostats in public areas and as shown on the Drawings.

d. Duct Temperature Sensor: The sensor shall measure the representative temperature of the entire cross-section of the duct or plenum. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces. Ductwork shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.
e. Fluid Temperature Sensors: Provide sensors with thermal wells fabricated and installed for the intended service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand all pressures, (including test pressures) and velocities to which they are subjected. Well shall not restrict flow area to less than 70 percent of line-size-pipe normal flow area. Where piping is smaller than the length of the well or exceeds the area requirements, the well shall be installed at an elbow and installed to effect uniform flow across the well. Sensors installed in wells shall be installed in horizontal piping below the pipe centerline.
f. Low Temperature Detection Thermostats: Mount sensor element similar to Mixed Air Temperature Sensors.

3. Current Sensors:

a. Provide flow proof for constant volume fans and pumps with a current sensor connected to the motor wiring at the starter. Set upper alarm limit to the maximum rated current of the motor, or as advised by the TAB Agency. Set lower alarm limit at 1/2 the motor running amps.
b. Provide flow proof for variable speed control system through utilization of the variable speed drive serial communication option. Drive will communicate directly with BAS system.

4. Digital Status, Digital Command Points, Lighting Controls:

a. Provide relays in a separate instrument enclosure or control panel adjacent to the monitored or controlled equipment. The relays shall mounted and connected in a manner that does not violate controlled equipment listing or code requirements.
b. Provide relays that operate in conjunction with the motor control system. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
c. Coordinate motor control requirements with Divisions 26, 27 and 28.
d. Coordinate lighting control requirements with Divisions 26, 27 and 28.

5. Identification:

   a. Panel and Instrument Enclosure Identification: Panels and instrument enclosures shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.
   b. Field Devices: Field devices shall be identified by a typed (not handwritten) securely attached tag label.
   c. Panel or Instrument Enclosure Devices: Devices shall be identified by a typed label securely fastened to the backplane of the local control panel or instrument enclosure.
   d. Wall Mounted Temperature Sensors: Device covers shall be identified by a typed label securely fastened to the front cover. The label shall indicate the terminal unit zone identification tag.
   e. Raceway Identification: The covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating “Control System” affixed to the covers. This requirement includes control system tubing. Labels shall be typed, not hand written.
   f. Wire Identification: Low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

3.2 SYSTEM STARTUP

A. Commissioning: Perform tests and verification procedures required for the commissioning process as requested by the Owner and directed by the Owner's Commissioning Authority.

3.3 MAINTENANCE

A. Arrange work so that wherever possible serviceable or operable products are located within mechanical or electrical spaces and are accessible.

END OF SECTION 253000

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for solid-state, pulse-width modulated (PWM) Adjustable Frequency Drives, herein referred to as AC Drives, for use with NEMA design AC motors. The term “VSD” (Variable Speed Drive) is also used in this specification.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 230593 - Testing, Adjusting and Balancing
7. 232123 - Hydronic Pumps
8. 233400 - HVAC Fans
9. 237413 - Packaged Rooftop Units
10. 253000 - Building Automation System Field Devices
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. Institute of Electrical and Electronic Engineers (IEEE): IEEE 519-2014.
3. Underwriters Laboratories (as appropriate): UL 508, 508A, 508C, UL 61800, 61800-5-1, 61800-5-2, UL 1995.
4. The Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA): NEMA ICS 7-2014, Adjustable Speed Drives.
5. National Electric Code (NEC): NEC 430.120, Adjustable-Speed Drive Systems.
6. CSA Group: CSA C22.2 No. 274.
7. International Building Code (IBC): IBC 2018 Seismic – referencing ASCE 7-16 and ICC AC-156.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. This specification is for a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with both asynchronous and permanent magnet motors.

B. The drive manufacturer shall supply the drive and all necessary options as specified. drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). Drives that are manufactured by a third party and "brand labeled" shall not be acceptable.

C. This specification is intended to supplement a drive schedule. The drive schedule identifies the optimized BOM for the project and includes quantity, size, voltage, enclosure rating, options, and harmonic mitigation requirements of the drives. IEEE 519-2014 is an electrical system standard for harmonic mitigation. Drives are a major source of harmonics, therefore the VFD manufacturer shall conduct a harmonic analysis for this particular jobsite to verify compliance with IEEE 519-2014.

1.4 PRE-INSTALLATION MEETINGS

A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Submittals shall include the following information:

1. Outline dimensions, conduit entry locations and weights. Customer connection and power wiring diagrams.
2. Complete technical product description with complete list of options provided. Any portions of this specification not met shall be clearly indicated or the Contractor shall be liable to provide all additional components required to meet this specification.
3. Submit shop drawings showing specific VSD mounting arrangements. Include verification that mounting of VSD complies with IBC chapter 16 requirements.
4. Clearly note any exceptions/deviations to this specification with the submittal.
5. Submit information from harmonic analysis demonstrating that the drives have proper internal harmonic mitigation and will not take the system out of compliance with IEEE Standard 519. Notify the Contracting Agency if additional mitigation measures are indicated.
6. Submit the following information:

    a. Combined harmonic content of all drives and combined harmonic content of all drives to be operated on generator.
    b. Amount of regenerated power put back into the distribution system from each drive (include drives operated on generator and drives only operated on normal power).

C. Closeout

1. Furnish two complete sets of Installation, Operation and Maintenance Manuals and other information necessary for the operation and maintenance of the system unless otherwise noted.
2. Submit Startup Service test results as specified under Start-up Service below.

D. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 QUALITY ASSURANCES

A. See Section 200000 - Mechanical General Requirements.

B. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR when installed in accordance with the manufacturer's guidelines.

C. The base drive shall be CE and meet EN 61800-3 for the First Environment restricted distribution (Category C2).

D. The base drive shall be seismically certified per 2018 International Building Code (IBC) with a seismic importance factor of 1.5, and minimum 2.5 SDS rating.

E. The base drive shall be SEMI-F47 certified. The drive must tolerate voltage sags to 50 percent for up to 0.2 seconds, sags to 70 percent for up to 0.5 seconds, and sags to 80 percent for up to one second.

1.7 DELIVERY, STORAGE AND HANDLING

A. See Section 200000 - Mechanical General Requirements.

1.8 WARRANTY

A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

B. Warranty shall be 24 months from the date of certified startup. The warranty shall include all parts, labor, travel time and expenses. There shall be 24/365 support available via a toll free phone number.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers are limited to the following:

1. ABB ACH 580 Series (basis of design).
2. Yaskawa.

3. Siemens SED2.

2.2 VARIABLE FREQUENCY DRIVES

A. The drive package as specified herein and defined on the drive schedule shall be enclosed in a NEMA Type 12 enclosure.

B. The drive shall provide full rated output from a line of +10 percent to -15 percent of nominal voltage across an ambient temperature range of -15 to 40 degrees C (5 to 104 degrees F).

C. Drives shall utilize the same Advanced Control Panel (keypad) user interface.

1. Plain English text:

   a. The display shall be in complete English words for programming and fault diagnostics.
   b. Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch or vibration trip. Customized terms, such as: AHU-1 End Switch or CT-2 Vibration shall also be available.

2. The control panel shall include at minimum the followings controls:

   a. Four navigation keys (Up, Down, Left, Right) and two soft keys.
   b. Hand-Off-Auto selection, Fault Reset, and manual speed control.
   c. A Help key shall include assistance for programming and troubleshooting.

3. There shall be a built-in time clock in the control panel with 10-year battery backup.
4. I/O Summary display with a single screen shall indicate and provide:

   a. The status/values of all analog inputs, analog outputs, digital inputs, and relay outputs.
   b. The function of all analog inputs, analog outputs, digital inputs, and relay outputs.
   c. The ability to force all inputs and outputs to either a high, low, or specific value.

5. The drive shall automatically backup parameters to the control panel. The drive shall allow two additional unique manual backup parameter sets to be stored.
6. The control panel shall be removable, capable of remote mounting.
7. The drive shall be able to support a Bluetooth Advanced Control Panel. The Bluetooth control panel shall be FCC and QDL (Qualified Design Listing) certified.

   a. A free app (iOS and Android) shall replicate the control panel on a mobile device or tablet. The control panel's programming and control functionality shall function on the device. Customizing text, such as AHU-1 End Switch, shall be supported by the device's keyboard.
   b. Bluetooth connectivity shall allow uploading, downloading, and emailing of parameters.
   c. Bluetooth connectivity shall include two pairing modes: Always discoverable with a fixed passcode, and manual discovery with a unique generated passcode every pairing.

D. Drives shall have the following hardware features/characteristics as standard:

1. Two (2) programmable analog inputs, two (2) programmable analog outputs, six (6) programmable digital inputs, and three (3) programmable Form-C relay outputs.
2. The drive shall include an isolated USB port for interface between the drive and a laptop.
3. An auxiliary power supply rated at 24 VDC, 250 mA shall be included.
4. At a minimum, the drives shall have internal impedance equivalent to 5 percent to reduce the harmonics to the power line. 5 percent impedance may be from dual (positive and negative DC link) chokes, or AC line reactor. Drives with only one DC link choke shall add an AC line choke integral to the drive enclosure. Reference the required harmonic analysis to determine if additional harmonic mitigation is required for the system to comply with IEEE 519-2014.
5. The combined harmonic content of all the drives on the project shall be small enough to not interfere with an emergency generator's voltage regulator. The impact of drives capable of regeneration on applications with a generator shall be verified. On projects where drives will be operated on generator include detailed information in submittals for both of these items to allow verification of impacts on generator operation.
6. The drive shall have variable speed primary cooling fans.
7. The overload rating of the drive shall be 110 percent of its normal duty current rating for 1 minute every 10 minutes, 130 percent overload for 2 seconds every minute.
8. The input current rating of the drive shall not be greater than the output current rating.
9. Circuit boards shall be coated per IEC 60721-3-3; Chemical gasses Class 3C2 and Solid particles Class 3S2.
10. Coordinated AC transient surge protection system consisting of 4 MOVs (phase-to-phase and phase-to-ground), a capacitor clamp, and internal chokes. The MOVs shall comply with UL 1449 4th Edition.
11. The drive shall include a robust DC bus to provide short term power-loss ride through. An inertia-based ride through function should help maintain the DC bus voltage during power loss events. Drives with control power ride through only, are not acceptable.

E. Drives shall have the following software features as standard:

1. A Fault Logger that stores the last 16 faults in non-volatile memory. The most recent 5 faults save at least 9 data points, including but not limited to: Time/date, frequency, DC bus voltage, motor current, DI status, temperature, and status words.
2. An Event Logger that stores the last 16 warnings or events that occurred, in non-volatile memory. Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, and automatic reset of a fault.
3. Programmable start methods: Flying-start, Normal-start, and Brake-on-start.
4. Programmable loss-of-load (broken belt / coupling) indication. This function to include a programmable time delay to eliminate false loss-of-load indications.
5. Motor heating function to prevent condensation build up in the motor. Motor heating adjustment, via parameter, shall be in "Watts."
6. There shall be a run permissive circuit for damper or valve control.
7. Four separate start interlock (safety) inputs shall be provided. The control panel will display the specific safety(s) that are open.
8. The drive shall include a switching frequency control circuit that reduces the switching frequency based on actual drive temperature. It shall be possible to set a minimum and a target switching frequency.
9. The ability to automatically restart after non-critical faults.

10. PID functionality shall be included in the drive.
11. Drive shall be compatible with an accessory that allows the control board to be powered from an external 24 VDC/VAC source.
12. A computer-based software tool shall be available to allow a laptop to program the drive. The drive shall be able to support programming without the need for line voltage. All necessary power shall be sourced via the laptop USB port.
13. The drive shall include a fireman's override mode.

F. Security Features:

1. The drive manufacture shall clearly define cybersecurity capabilities for their products.
2. The drive shall include password protection against parameter changes. There shall be multiple levels of password protection including: End User, Service, Advanced, and Override.
3. A checksum feature shall be used to notify the owner of unauthorized parameter changes made to the drive.
4. The "Hand" and "Off" control panel buttons shall have the option to be individually disabled (via parameter) for drives mounted in public areas.

G. Network Communications:

1. The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, and Johnson Controls N2. Optional communication cards for BACnet/IP and LonWorks shall be available.
2. The drive shall have the ability to communicate via two protocols at the same time, one onboard protocol and one option card-based protocol.
3. The drive shall not require a power cycle after communication parameters have been updated.
4. The embedded BACnet connection shall be a MS/TP interface. The drive shall be BTL Listed to Revision 14 or later.

H. Disconnect:

1. A circuit breaker type disconnect shall be provided.
2. The disconnect shall be door interlocked and padlockable.
3. Drive input fusing shall be included on all packaged units that include a disconnecting means.
4. Disconnect configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

I. A manual bypass system is not desired or required.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that jobsite conditions for installation meet factory-recommended and code-required conditions for VSD installation prior to start-up. These shall include as a minimum:

1. Clearance spacing.
2. Temperature, contamination, dust, and moisture of the environment.
3. Conduit installation of the motor wiring and power wiring separation.

3.2 INSTALLATION

A. VSDs shall be furnished under Division 25 and installed under Division 26. The contractor shall install the drive in accordance with the recommendations of the VSD manufacturer as outlined in the installation manual.

B. Power wiring shall be provided under Division 26. The contractor shall complete wiring in accordance with the recommendations of the VSD manufacturer as outlined in the installation manual.

C. Verify that the location is ready to receive work and the dimensions are as indicated.

D. Do not install VSD until the building environment can be maintained within the service conditions required by the manufacturer. Before and during the installation, the VSD equipment shall be protected from site contaminants. The VSD shall be covered and protected from construction dust and contamination until the environment is cleaned and ready for operation. The VSD shall not be operated while the unit is covered.

E. Details of the installation shall comply with the manufacturer's applicable instructions.

F. Minimize the length of conductors between the drive and the motor to avoid motor damage from reflected wave phenomenon.

G. Mounting of VSD shall be suitable for seismic anchorage and/or restraints as required by International Building Code.

3.3 WIRING

A. Conductors feeding Variable Frequency Drives (VFDs) and between VFDs and equipment supplied by the VFDs shall be Type XHHW-2.

3.4 CONTROL WIRING

A. Control wiring and control devices shall be provided under the specification section in which the controlled equipment is specified. Coordinate related work.

B. Control wiring shall be routed completely separately from power wiring.

3.5 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VSD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

B. A computer based training CD shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VSD and serial communication.

3.6 FIELD QUALITY CONTROL

A. Start up: Certified factory startup shall be provided for each drive by a factory authorized service center. A certified startup form shall be filled out for each drive with copies submitted and included in the O&M Manuals, and a copy kept on file by the manufacturer.

B. Training: Onsite training shall be provided as part of the startup service. The training shall include installation, programming, and operation of the VSD and serial communication.

C. Document each installation and operational step utilizing the approved PC/FC checklists in accordance with Section 01 9100 - Commissioning.

3.7 ADJUSTING

A. Coordinate hydronic and ventilation system static pressure control set points with Section 23 0593 - Testing, Adjusting and Balancing. Make necessary corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.8 CLEANING

A. Upon completion of installation and prior to initial operation, vacuum clean and wipe down VSD enclosures. Remove debris for interior of enclosures.

END OF SECTION 254000

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: This section describes requirements, products, and methods of execution relating to the building automation controls system for the project.

B. Related Sections: Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 226300 - Medical Gas Systems
4. 230593 - Testing, Adjusting and Balancing
5. 232113 - Hydronic Piping and Specialties
6. 232113 - Hydronic Pumps
7. 233100 - Ducts and Accessories
8. 233400 - HVAC Fans
9. 233600 - Air Terminal Units
10. 235216 - Condensing Boilers and Accessories
11. 237416 - Packaged Rooftop Units
12. 238123 - Dedicated Air-Conditioning Units
13. 238200 - Terminal Heating and Cooling Units
14. 253000 - Building Automation System Field Devices
15. 259000 - Sequence of Operations
16. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards. Perform work in accordance with applicable national, state and local codes to include:

1. See Section 200000 - Mechanical General Requirements.
2. ANSI-C2, National Electrical Safety Code - NESC.
3. Underwriters Laboratory (UL) or approved equal.
4. Institute of Electrical and Electronics Engineers - IEEE.
5. National Electrical Manufacturers' Association - NEMA.

B. Abbreviations and Acronyms:

1. Building Automation System (BAS).
2. Direct Digital Control (DDC).

C. Definitions:

1. ASHRAE: The American Society of Heating, Refrigerating and Air-Conditioning Engineers.
2. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135-current edition, developed under the auspices of ASHRAE.
3. Bridge: A device that routes messages or isolates message traffic to a particular segment, sub-net, or domain of the same physical communication media.
4. Building Automation System (BAS): Collection of sensors, operators, controllers, and interconnecting wiring that control the operation of the building mechanical and electrical systems as described in these specifications.
5. Field device or field control device: A physical component such as a temperature sensor, pressure sensor, contact, motor operated valve, and motor operated damper. Generally considered to bring only one point to a controller.
6. Gateway: A hardware/software package that allows communication between dissimilar ("foreign") systems and different protocols. Gateways are typically custom built, configured, and used only for transmitting and receiving data between different systems. System programming through gateways is not possible within the scope of this definition.
7. LonTalk: An open protocol for communication developed privately by the Echelon Corporation in Palo Alto, California.
8. Operator workstation: The central personal computer for the user to implement day to day operation of the system.
9. Router: A device for connecting different local-area network segments within a network. Routers that are used between networks with different protocols are limited. Point mapping in this type of router is automatic and requires less than one hour to configure. This device is not capable of storing point map information.
10. TCP/IP (Transmission Control Protocol/Internet Protocol): The communication language or protocol that defines the Internet. TCP/IP can also be used as a communication protocol in private networks.
11. Terminal Unit Controller: A device to control very specific applications such as a VAV box, cabinet unit heater, fan terminal unit and the like. These units may have predefined operating sequences with limited custom programming available. (Also called an "application specific controller").

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. The HVAC Control System will consist of a flat, open architecture based upon BACNet meeting the requirement of ANSI/EIA 709.1 and ASHRAE Standard 135. Provide necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.
2. The system shall operate as a low-voltage multiplexed data system. The controls and instrumentation specified herein shall be integrated and installed as a complete package by the Contractor.
3. The completed system shall be integrated such that graphics, reports, and system interfaces from the Operators workstation appears as if there is one system.
4. No BAS system components requiring the use of gateways will be accepted.

5. To provide future flexibility, router domains shall not exceed nominally 75 percent of the maximum number of devices in the domain, unless specified otherwise.

B. Performance Requirements:

1. This section specifies the requirements for the BAS to be installed in conjunction with this project.
2. Controls contractor shall furnish and install an integrated building automation system, incorporating DDC for energy management, equipment monitoring and control, and subsystems as herein specified. Controls contractor will complete the temperature control system as specified herein.
3. Materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. Systems and components shall have been thoroughly tested and proven in actual use for at least two years.
4. Controls contractor shall be responsible for BAS and temperature control wiring for a complete and operable system. Wiring shall be done in accordance with Divisions 26, 27 and 28 of this specification and local and national codes.
5. Control and monitoring for mechanical systems installed under this Contract, including:

    a. Building ventilation systems.
    b. Building heating systems.
    c. Domestic water heater trouble/alarm monitoring.
    d. Dental air and vacuum system trouble/alarm monitoring.

6. The Work under this Section includes furnishing and installing wiring, conduit, connectors, terminal strips, and any other equipment required to interface each sensor or control point to the control system.
7. Provide control system and subsystem network cabling, routers, and other devices required for the systems shown and specified, except as specifically noted or shown on the drawings.
8. Providing sequences of operation described in Section 259000 - Sequence of Operations.
9. Installation of control instrumentation and hardware specified in Section 253000 - Building Automation System Field Devices, necessary for a complete system of controls.
10. Integrating the controls under this Contract with the Owner's HVAC Supervisory System.
11. Commissioning support activities as required in 019100 - Commissioning, including requirements in development of commissioning checklists, phased commissioning, installation examination and performance test activities, training and IO&M requirements. BAS contractor shall provide field and office support of commissioning activities.
12. System functional requirements include, but are not limited to:

    a. BAS system shall provide all normal and off-normal control functionality without reliance upon PC file server or workstation.
    b. Programming information, graphics, databases, and other information required to restore the entire system in the event of equipment failure or malfunction or human error shall be protected with a centralized back-up system.
    c. Systems shall be designed to maximize multiple-vendor flexibility to replace or modify any portion of the system.

13. Software upgrades for PC and control network operating systems, the supervisory system, web browser, programming/binding tools, etc., without limitation shall be provided at no additional charge for a period of one year after Substantial Completion of the BAS.

14. A training program shall be provided to include: Data acquisition and report generation on the Operator's workstation.
15. The cost of providing power from the building electrical system shall be included in the bid. Power sources are subject to submittal requirements, and review and approval.

1.4 PREINSTALLATION MEETINGS

A. Coordinate installation of the building automation system with trades responsible for portions of this and any other related sections of the Project Manual prior to installation of any components.

1.5 SUBMITTALS

A. Refer to Section 200000 - Mechanical General Requirements for general submittal requirements.

B. Product Data:

1. Provide manufacturer's literature that demonstrates compliance with the manufacturing methods, appurtenances and salient features specified.
2. Equipment tagging method specifically listing each device and the identification tag to be applied.
3. Sequence of Operations.
4. Riser Diagrams.
5. Control Diagrams.
6. Panel layouts.
7. Valve and Damper schedules.
8. Point Summary Report.
9. Blank (Reserved for Enhanced Alarm Report).
10. Blank (Reserved for Commented PPCL).
11. Blank (Reserved for Trend Logs).
12. Blank (Reserve for Electronic Plans Room file).

C. Shop Drawings:

1. Riser Diagrams.
2. Control Diagrams.
3. Panel layouts.
4. Valve and Damper schedules.

D. Quality Control Submittals:

1. Pre-functional Installation (PC) and Functional Performance Test (FT) Checklists in accordance with Section 019100 - Commissioning.
2. Incorporate BAS control requirements into the applicable equipment PC/FT checklists.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Contracts: Include information on any maintenance contract with Owner.

B. Operation and Maintenance Data. The O&M Manuals will consist of the following (Progression from Submittal to O&M Manual takes place using the same binders):

1. Sequence of Operations.
2. Riser Diagrams.
3. Control Diagrams.
4. Panel layouts.
5. Valve and Damper schedules.
6. Point Summary Report.
7. Enhanced Alarm Report.
8. Commented PPCL (Program Code).
9. Trend Logs.
10. Product Data including items reused from existing control system as noted.
11. Electronic Plans Room file.

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturers: Companies specializing in manufacturing the products specified in this section with a minimum of three (3) years documented experience.
2. Installers: Minimum three (3) years' experience in the installation, programming and start-up of building automaton systems.
3. Testing Agencies: Regulatory requirements for products requiring electrical connection – Listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the MOA.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Verify equipment and associated appurtenances are delivered in original factory packaging/crating and are free from damage and corrosion.
2. Replace equipment delivered to job site that does not comply with above requirements at no expense to the Owner.

B. Storage and Handling Requirements:

1. Store products in covered storage area, protected from the elements, outside the general construction area until installed.
2. Handle items carefully to avoid breaking, chipping, denting, scratching, or other damage.
3. Replace damaged items with same item in new condition.

1.9 WARRANTY

A. Manufacturer Warranty:

1. Provide in accordance with Section 200000 - General Mechanical Requirements.

2. Provide maximum 4 hour response time to service/warranty calls from the Owner during the warranty period.

B. Special Warranty:

1. The warranty shall consist of a commitment by controls contractor to provide, at no cost to the Owner, parts and labor as required to repair or replace such parts of the control system that prove inoperative due to defective materials or installation practices.
2. The warranty expressly excludes routine service such as instrument calibration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Existing facility Building Automation System is Johnson Controls.

1. Building Automation System for this project shall match existing.

B. Management Level Network (MLN). Acceptable manufacturers are limited to the following:

1. Johnson Controls.
2. No Alternate Brand Request; no Substitution Request.

C. Building Level Network (BLN). Acceptable manufacturers are limited to the following:

1. Johnson Controls.
2. No Alternate Brand Request; no Substitution Request.

D. Floor Level Network (FLN). Acceptable manufacturers are limited to the following:

1. Johnson Controls.
2. No Alternate Brand Request; no Substitution Request.

2.2 APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:

1. Application Specific Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The ASC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.

4. ASC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement.

B. ASC Interface Software:

1. General: ASC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of ASC shall not be required for configuration.
2. ASC shall provide a selection of control applications performable through configuration of the device. Download of new application should not be required for one of these applications.

C. ASC Device Software:

1. General: An ASC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage network communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.

2.3 APPLICATION GENERIC CONTROLLER (AGC)

A. General Requirements:

1. Application Generic Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The AGC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
4. AGC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. Network and power wiring shall allow for ‘pass-thru’ of signal when electronic boards are removed.

B. AGC Interface Software:

1. General: AGC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of AGC shall not be required for configuration.

2. AGC shall provide a selection of control applications performable through configuration of the device. Download of new applications from network management tool shall be possible, but not required.

2.4 CUSTOM APPLICATION CONTROLLER (CAC)

A. General Requirements:

1. Custom Application Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. CAC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.
4. CAC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. The complete CAC including accessory devices such as relay, transducers, power supplies, etc. shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.
5. Equip CAC's with diagnostic indicators for the following:

    a. Transmit.
    b. Receive.
    c. Power up test.
    d. Power up fail.
    e. Power up test okay.
    f. Bus error.

B. CAC Software:

1. General: A CAC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage CAC to OI communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.
3. Input/Output Point Processing Software shall include:

    a. Continuous update of input and output values and conditions. Connected points are to be updated at a minimum of one-second intervals.
    b. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32 bit floating point format. Both the maximum and minimum values sensed for each analog input are to be retained in memory. It shall be possible to input subsets of standard sensor

ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.

c. A reasonability check on analog inputs against the previously read value and discard those values falling outside pre-programmed reasonability limits.
d. Assignment of proper engineering units and status condition identifiers to analog and digital input and outputs.
e. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and actual alarm) to an input or to assign a set of floating limits (alarm follows a reset schedule or control point) to the input. Each alarm shall be assigned a unique differential to prevent a point from oscillating into and out of alarm. Alarm comparisons shall be made each scan cycle.
f. Debounce of digital inputs to prevent nuisance alarms. Debounce timing shall be adjustable from two seconds to two minutes in one second increments.

4. Alarm lockouts:

a. Alarm lockout software shall be provided to prevent nuisance alarms. on initial start-up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period is to be programmable on a per point basis from 0 to 90 minutes in one minute increments.
b. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when true alarm is dependent on the condition of an associated point. Hard lockout points and lockout initiators are to be operator programmable.
c. Design the power supply to accommodate the power requirements of all components (or nodes) connected, plus 50 percent.

5. Run Time Totalization or Point Trending:

a. Run time shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Run time counts shall be resident in non-volatile memory and have CAC resident run time limits assignable through the operator's terminal.
b. Totalized run time or trended data shall be batch downloaded using FTP to the SS on a daily or weekly basis. Trended data shall reside on the SS database server. The automatic update of this data shall be determined by the SS and facility management application requirements.

6. Transition Counting:

a. A transition counter shall be provided to accumulate the number of times a device has been cycled on or off.
b. Counter is to be non-volatile and be capable of accumulating 600,000 switching cycles.
c. Limits shall be assignable to counts to provide maintenance alarm printouts.

7. Custom Direct Digital Control (DDC) Loops:

a. Custom DDC programs are to be provided to meet the control strategies as called for in the sequence of operation sections of these specifications.

b. Each CAC shall have residential in its memory and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences:

1). Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning): The adaptive control algorithm shall be used on control loops, as indicated in I/O summary, where the controlled medium flow rate is variable (such as VAV units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that on system shutdown and restart, the learning process starts from where it left off and not from ground zero. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.

2). DDC setpoints, gains and time constants associated with DDC programs shall be available to the operator for display and modification via the SS operator interface.

3). The execution interval of each DDC loop shall be adjustable from 2 to 120 seconds in one-second increments.

4). DDC control programs shall include an assignment of initialization values to outputs to assure that controlled devices assume a fail-safe position on initial system start-up.

2.5 VAV CONTROLLERS

A. Provide manufacturer's thermostat matched to controller. Refer to Section 253000 - Building Automation System Field Devices, for requirements.

B. Coordinate with Section 233600 - Air Terminal Units to have VAV controllers factory mounted on the VAV terminal unit.

C. For applications requiring consistent airflow for space pressure control, provide VAV controllers with an auto-zero module to allow for periodic airflow sensor calibration without interruption of airflow.

2.6 ROUTERS, BRIDGES, REPEATERS AND TRANSCEIVERS

A. Routers, Bridges and Repeaters:

1. Equip each router and bridge with a network transceiver on each network port (inbound and outbound) as dictated by the network type (Type 1 - FTT, Type 2 - TP, Type 3 - PL, Type 4 - LP, Type 5 - RF).
2. The network router shall be designed to route messages from a segment, sub-net, or domain in full duplex communication mode.
3. Routers with TCP/IP capability shall be provided where TCP/IP backbone is used.

4. Routers, bridges and repeaters shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions.
5. The routers, bridges, and repeaters shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power.

B. Transceivers:

1. Type 1 Network Transceiver, Free Topology, Twisted Pair: Provide a transformer isolated, twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:

   a. Differential Manchester encoded signaling for polarity insensitive network wiring.
   b. Transformer isolated for common mode rejection.
   c. 78 Kbps network bit rate up to distances of 2000m.
   d. Free topology supports star, home run, multi drop and loop wiring topologies.
   e. Complies with FCC and VDE requirements.
   f. UL recognized component.

2. Type 2 Network Transceiver, Twisted Pair: Provide a transformer isolated twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:

   a. Differential Manchester encoded signaling for polarity insensitive network wiring.
   b. Transformer isolation for common mode rejection.
   c. 1.25 Mbps network bit rate up to distances of 1000 meters.
   d. Unpotted construction.
   e. Less than 1 mA power consumption with +5VDC input voltage.
   f. FCC and VDE Level B requirements compliance.
   g. UL Listed.

3. Type 3 Network Transceiver, Power Line:

   a. Provide a direct sequence, spread spectrum power line transceiver which is equipped with the following signal processing and error correction capabilities to provide robust and error free communications.

      1). Forward Error Correction (FEC) to enable the system to read and reconstruct corrupted packets without sacrificing throughput. The FEC shall require only six percent overhead for error correction.
      2). Automatic sensitivity adjustment algorithm that dynamically changes the receiver sensitivity based on noise characteristics.
      3). Oversampling correlation filter and adaptive data recovery algorithm to synchronize instantaneously to incoming packets.
      4). Tri-state power amplifier/filter combination to provide a powerful output signal with a minimum number of components.

   b. The transceiver shall be able to operate using the controller power supply and coupling circuit. Provide the following general features as a minimum:

      1). Packaged in a rugged, potted module.
      2). Programmable clock output (1.25, 2.5, 5 or 10 Mhz).

3). 10 Kbps network transmission rate.
4). Packet detect output to drive a status indicator LED.
5). Minus 20 to plus 85 degrees C. operating temperature range.
6). UL Listed.

4. Type 4 Network Transceiver, Link Power: Provide a twisted pair transceiver that utilizes the twisted pair communication media to provide power for Controller(s). The transceiver shall meet the following specifications:

a. Free single-in-line package (SIP) construction.
b. Send both network data and power on a twisted wire pair.
c. Differential Manchester encoded signaling for polarity insensitive network wiring.
d. 78 Kbps network bit rate up to distances of 320 meters.
e. Supports star, home run, multidrop, and loop wiring.
f. Supplies +5VDC @ 100 mA maximum for node power.
g. Compliance with FCC and VDE requirements.
h. UL Listed.

5. Type 5 Network Transceiver, Radio Frequency: Provide a direct sequence, spread spectrum RF transceiver that meets the following specifications:

a. 100 meter open field range.
b. Wireless communications extends network between buildings and to vehicles and portable devices.
c. FCC type certifiable, 48 MHz.
d. Low-cost miniature circuit board, SMT components.
e. Carrier detect output to drive a status indicator LED.
f. Plus 7 to plus 15VDC input voltage.
g. Minus 20 to plus 60 degrees C. operating temperature range.

2.7 OPERATOR WORKSTATION

A. The central personal computer for the user to implement day to day operation of the system. The workstation is generally capable of allowing the operator to accomplish the following functions:

1. Operate in a network environment.
2. Monitor the entire control system.
3. Change set points.
4. Maintain, set, and monitor alarms.
5. Maintain and monitor operating schedules.
6. Control interactively using graphical representations of the system.
7. Manually command points.
8. Trend the behavior of selected points.
9. Archive history.
10. Backup data.
11. Print results.
12. Modify custom programs and sequences of operation.

2.8 PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE

A. A new graphical operator workstation "client" shall be provided as specified in this section. The new client workstation shall communicate directly with the existing controls database server. Communication shall take place over the Owner's existing Wide Area Network. Programming, graphics and databases created as part of this project shall be incorporated into the existing controls system. Provide a complete, secure backup of the host database at the completion of this project.

B. Provide one graphical operator workstation for command entry, information management, network alarm management and database management functions. The workstation shall communicate seamlessly with the existing Alerton controls system.

1. Provide one workstation of equal or greater capability located as indicated on the contract documents.
2. Workstation shall consist of a personal laptop computer with minimum Windows 10 Pro, 11th Generation Intel Core i7 processor (8 Cores), 16GB RAM, 1 TB solid state hard drive, minimum 16" screen size, video card capable of supporting 1920 × 1080 or above, integrated webcam, USB 3.0 (Type-A and Type-C), WiFi 6, Gigabit network interface card, trackpad, Bluetooth mouse and Kensington combination laptop lock with tamper resistant desk mount anchor point.

2.9 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description:

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30-character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:

   a. Real-time graphical viewing and control of environment.
   b. Scheduling and override of building operations.
   c. Collection and analysis of historical data.
   d. Point database editing, storage and downloading of controller databases.
   e. Alarm reporting, routing, messaging, and acknowledgment.
   f. Display dynamic data trend plot.
   g. Definition and construction of dynamic color graphic displays.
   h. Program editing.
   i. Transfer trend data to third party software.
   j. Scheduling reports.
   k. Operator Activity Log.

2. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.
3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The operator shall be able to work in Microsoft Word,

Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.

4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).
5. Scheduling and Override: Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key.
6. Collection and Analysis of Historical Data: Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

B. Dynamic Color Graphic Displays:

1. Create at least one color graphic display for each piece of mechanical equipment, including air handling units, hot water boiler systems, and room level terminal units. Provide floor plans to facilitate navigation. Point information to be displayed on the graphics shall be provided by the BAS contractor to optimize system performance and analysis and to speed alarm recognition.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of submittal AutoCAD drawings and scanned pictures for use in the system.
3. Dynamic temperature values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
4. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
6. A dynamic display of the site-specific architecture showing status of controllers, PC workstations and networks shall be provided.

C. System Configuration and Definition:

1. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
2. Provide automatic backup and restore of DDC controller databases on the workstation hard disk. In addition, database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and

downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

D. Alarm Management:

1. Alarm Routing shall allow the user to send alarm notification to selected PC locations based on time of day, alarm severity, or point type.
2. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
3. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

E. 3 (BLN) and DDC Controller floor level local area networks (FLN). Access to the system shall be totally transparent to the user when accessing data or developing control programs.

F. Management Level Network:

1. PCs shall simultaneously direct connect to the Ethernet and Management Level Network without the use of an interposing device.
2. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
3. Simultaneous user access to network limited to number of sight licenses issued to user.
4. When appropriate, any DDC controller residing on the peer-to-peer building level network shall connect to Ethernet network without the use of a PC.
5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet as well as directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network in addition to being able to download program changes to individual controllers.
6. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
7. Access to the system database shall be available from any client workstation on the Management Level Network.

G. Peer-to-Peer Building Level Network (BLN):

1. The system shall have the ability to support integration of third party systems (fire alarm, security, lighting, variable speed drives, PLCs, condensers, boilers) via a panel mounted open protocol processor. This processor shall exchange data between the two systems for inter-process control. Exchange points shall have full system functionality as specified herein.
2. Data transfer via Ethernet.

H. Floor Level Network (FLN): This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

2.10 CONTROL PANELS

A. Terminal Equipment Controllers will be mounted in enclosed control panels with screwed, removable covers.

B. Control devices located in exposed areas subject to outside weather conditions or near circulator pumps (spray due to shaft seal failures) shall be mounted inside weatherproof enclosures. Location of each panel shall be convenient for adjustment service.

C. Nameplates shall be provided beneath each panel face mounted control device describing the function of each device. Nameplates shall have white letters engraved on blue Lamicoid, or approved equal.

D. Control panels shall bear a UL label compatible with the application.

E. Electrical devices within the panel shall be pre-wired to terminal strips, with inter-device wiring within the panel completed prior to installation of the system.

F. BLN level controllers shall be provided with standby/emergency power to provide power quality and minimum 15 minutes operation.

2.11 UNINTERRUPTIBLE POWER SUPPLY

A. Acceptable manufactures are limited to the following:

1. Powerware.
2. Alternate Brand Request or Substitution Request required.

2.12 ACCESS PANELS

A. Access panels provided by Section 083113.

B. Coordinate access panel location with the Owner’s Representative and Section 083113. Provide access to concealed control devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:

1. Mount damper operators and other control devices secured to insulated ductwork on brackets such that the device is external of the insulation. See Section 200529 - Hangers and Supports.
2. Do not install control devices in locations where they are subject to damage or malfunction due to normally encountered ambient temperatures.

3. Identification: Permanently tag controllers, switches, relays, thermostats and actuators for identification using the tagging format shown on the BAS control drawings.
4. Sensors and Switches:

    a. Pump flow or fan flow, etc., shall be sensed using current switch unless indicated otherwise. Calibrate current switch to distinguish between loaded or unloaded motor condition due to belt or coupler breakage.
    b. Protect averaging or capillary tubes where they penetrate duct with rubber grommet and seal with clear silicon. Support with capillary clips and maintain minimum 1 inch tubing bending radius.

5. Wiring:

    a. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. Install wiring in exposed or inaccessible areas in EMT conduit. Plenum-rated cable may be used in concealed, accessible areas only.
    b. Provide wiring between thermostats and unit heater motors, and control and alarm wiring.
    c. Provide conduit and wiring between the BAS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit or plenum-rated cable.
    d. Provide conduit and control wiring for devices specified in this Section.
    e. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BAS panels located in the vicinity of motor control centers.
    f. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contactors, and BAS panels, as shown on the drawings or as specified.
    g. Wiring shall be compliant with the Divisions 26, 27 and 28 requirements and the NEC.
    h. Provide electrical wall boxes and conduit sleeves for wall-mounted devices. Mount thermostats at 44 inches AFF unless otherwise noted.
    i. Ethernet drop at or near designated BAS control panel(s), and as needed.

B. Interface with Other Work:

1. The Contractor is responsible to furnish and install complete and operational systems. The following breakdown is recommend; carefully coordinate work between subcontractors.

2. Products furnished by BAS contractor for installation by the mechanical contractor:

    a. Control valves.
    b. VAV box controllers.

3. Products furnished and installed by mechanical contractor:

    a. VAV boxes. BAS contractor shall furnish VAV box controls to the VAV box manufacturer for factory installation at the expense of the box manufacturer.
    b. VAV box controller enclosures will be provided by box manufacturer.

c. Gauges, thermometers and thread-o-lets for BAS contractor furnished control sensor wells.
d. Airflow measuring stations.
e. Control and balancing dampers.
f. Smoke and fire/smoke dampers actuators.

4. Electrical contractor (Div. 26) provides:

a. Wiring of power feeds through disconnect starters to electrical motors.
b. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by controls contractor.
c. Duct smoke detectors including installation and wiring.
d. Power wiring of smoke/fire dampers provided by Divisions 20, 21, 22, 23, 25.
e. Stand-alone packaged controls and wiring of stand-alone packaged controls to their remote sensors and devices.

C. System Integration. Products to receive integration under this section:

1. Fire Alarm/Life Safety System:

a. The BAS shall communicate with the fire alarm/life safety system via an alarmable point in the form of a dry contact.
b. The device will be provided and terminated by Divisions 26, 27 and 28. This section will provide wiring to the termination device.

3.2 PROGRAMMING

A. Programming and graphics shall be included to implement the controls sequences specified in Section 259000 - Sequence of Operations, and to implement the systems and features included in Facility Services Divisions 20-28. It shall not be necessary for the Contracting Agency to further program the system.

B. Provide licensed copies of software tools and programming aids used to install, develop and troubleshoot the controls system to the Contracting Agency. Assist the Contracting Agency in registering the software in Contracting Agency's name.

C. Implement the control sequences for the equipment on this project as contained in Section 259000 - Sequence of Operations.

D. Point identifiers shall be chosen for easy identification of the actual equipment being controlled or monitored. They shall include equipment tag identifiers shown on the drawings, and may include additional characters to identify floor, area, etc. Maintain a listing of identifiers used in this project, with their plain English names. Submit the listing for review and information.

3.3 GRAPHICS

A. Graphical Mechanical Displays: Create graphical displays of major mechanical equipment for this project and install graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans derived from architectural AutoCAD representations and graphical representations of the equipment controlled under this contract.

1. Plans:

   a. Provide a central site plan for the entire facility and immediate surroundings. As a minimum indicate the following:

      1). Area designation.
      2). Number of levels on each area.
      3). Adjacent street names.
      4). North arrow.

   b. Provide floor overall floor plans for each level of the facility. As a minimum indicate the following:

      1). Area designation and level.
      2). Mechanical and electrical rooms.
      3). Control panel locations.
      4). North arrow.

   c. Provide individual floor plans for the facility. As a minimum indicate the following:

      1). Walls, doors, and general floor plan arrangement.
      2). Mechanical and electrical rooms.
      3). Temperature sensors.
      4). Temperature control zones.
      5). Control panel locations.
      6). North arrow.
      7). List of major HVAC systems serving the area including but not limited to the following:

         a) Air handling systems.
         b) Exhaust fans.
         c) Toilet exhaust fans.
         d) Heating systems.
         e) Cooling systems.

   d. As a minimum provide the following functional links on for each floor plan:

      1). Provide links back and forth between the plan screens noted above.
      2). On floor plan with temperature sensor, provide dynamic color coding for each sensor as follows:

         a) Blue indicates space temperatures less than 65 degrees F.
         b) Green indicates space temperatures between 66 degrees and 74 degrees F.
         c) Red indicates space temperatures above 75 degrees F.

      3). Provide a link to each VAV terminal unit from the associated temperature sensor.
      4). Provide a link to each major mechanical system serving the temperature sensor.

2. Room Reheat coils:

a. Indicate the following information for each unit:

1). Room Temperature.
2). Coil valve position percent.
3). Fintube valve position percent.

3. Air Handling: Indicate the following information for each AHUs/MAUs, relief/exhaust fans, and toilet exhaust fans:

a. Put control points and adjustable set points on the screen.
b. Define action of dampers and valves (N/O or N/C);
c. Fan schedule override commands.
d. Reset schedules.
e. Outside air CFM and minimum requirement.
f. Duct static set point.

B. Use approved designations for room names, spaces, equipment tags, etc.

3.4 SITE QUALITY CONTROL

A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

B. Programming BAS to provide system operation and monitoring in accordance with Section 259000 - Sequence of Operation and other referenced sections.

C. Trend Logs:

1. Prepare trend logs for all points required to demonstrate BAS calibration, control and stability.
2. Trend logs shall document building operation after applicable PC/FT checklists are completed and building site commissioning is satisfactorily completed.
3. Set points, valve positions, etc. may be temporarily adjusted to artificially induce the intended sequences to occur.

3.5 CLOSEOUT ACTIVITIES

A. Demonstration:

1. Provide demonstrations in accordance with Section 017900 - Demonstrations and Training.
2. Demonstrate the proper operation and control of systems controlled and monitored by the BAS.
3. The demonstration shall include, but not necessarily be limited to, the following:

a. Review of the Trend Logs.
b. Complete and proper operation of control systems including simulations.
c. Access to devices for required maintenance.
d. Review of associated graphics on Host.

B. Training:

1. Provide training in accordance with Section 017900 - Demonstrations and Training.
2. In addition, provide eight (8) hours of on-site instruction by BAS contractor to familiarize operating personnel with the control system. Instructions will include:

   a. A brief description of the controls' sequence of operation.
   b. A discussion and explanation of alarms, switches and gauges.
   c. A summary and explanation of steps to be taken in response to specific alarms or control malfunctions.
   d. Building walk-through to physically locate and examine control devices and demonstrate control setpoint adjustment procedures.
   e. Instructions regarding adjustment procedures shall emphasize methods for continual building "fine-tuning".

END OF SECTION 255000

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: This section describes the building automation system (BAS) control sequences for the heating, ventilating, and air-conditioning (HVAC) systems, electrical systems and plumbing systems provided for this project.

B. Related Sections: Refer to Section 255000 - Building Automation System

1.2 REFERENCES

A. Refer to Section 255000 - Building Automation System.

1.3 SYSTEM DESCRIPTION

A. Refer to Section 255000 - Building Automation System.

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 255000 - Building Automation System.

1.5 SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

B. Product Data:

1. Provide BAS manufacturers' product literature, clearly annotated to indicate performance criteria to include the following:

   a. Building level to floor level network controller riser diagrams. Include building locations and equipment controlled by each controller.
   b. Sequences of operation for HVAC, electrical and plumbing systems.
   c. Process control diagrams to support each sequence of operation. Show field mounted control device locations and circuit routing.
   d. Complete electrical and pneumatic BAS points list.

C. Quality Assurance/Control Submittals:

1. Installation and Functional Performance Test Letter.

   a. Provide a letter certifying that the building automation system hardware is completely installed and sequences of operation have been programmed,

operationally tested, with physically verification, to comply with the sequences of operation as specified. The installer(s), sub-contractor(s) and the Contractor must sign the letter.

b. Include as an attachment, a list of programming deviations from the specified sequences of operation with justification to support each deviation.

c. Include as an attachment, a table of final adjustable setpoint values for each applicable control point.

D. Installation, Operation and Maintenance Data:

1. Refer to Section 200000 – Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
2. Provide approved submittal information, revised to reflect the actual installation as addressed in the attachments provided with the Installation and Functional Performance Test Letter, for inclusion within the project IO&M Manual.

1.6 CLOSEOUT SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

A. Refer to Section 255000 - Building Automation System.

B. Qualifications of Installers/Programmers: Minimum 3 years' experience in the installation and programming of direct digital control systems.

1.9 WARRANTY

A. Refer to Section 255000 - Building Automation System.

PART 2 - PRODUCTS - Not Used

PART 3 - EXECUTION

3.1 MEDICAL GAS ROOM EXHAUST FAN (EF-3) AND ROOM TEMPERATURE CONTROLS

A. Exhaust Fan:

1. Fan operates continuously 24 hours per day and 7 days per week.
2. Monitor fan operating status via current sensor and generate trouble alarm if fans fail to run when commanded.
3. Manually activated emergency shut down switch and manually activated audible and visual room alarm for medical gas storage rooms by Division 28 as noted on drawings. Coordinate with Divisions 26, 27, and 28.

B. Room Temperature Controls and Monitoring:

1. Set room temperature at 60 degrees F (adjustable).
2. Provide room temperature monitoring and alarming capabilities via the BAS system to generate alarm if room temperature drops below 45 degrees F (adjustable).

3.2 GENERAL BUILDING EXHAUST FAN OPERATION (EF-2)

A. Exhaust fan EF-2 provides general building exhaust for toilet rooms, lab, closed dental treatment rooms, sterile processing department, locker rooms, etc. throughout the building. Operate exhaust fan as follows:

1. Open motor operated exhaust fan backdraft damper and start exhaust fan at 6 a.m. (adjustable).
2. Stop exhaust fan and shut motor operated backdraft damper at 9 p.m. (adjustable).
3. Monitor exhaust fan motor and generate a fan specific “EF-2 Trouble” alarm when exhaust fan fails to operate when commanded.

3.3 VENTILATION SYSTEM (RTU-1)

A. General Ventilation System Description:

1. The ventilation systems consist of two centralized roof top air-handling units (RTU-1 and RTU-2) located on the roof. The roof top units serve the following areas:

   a. RTU-1: Basement, Level 1, and a portion of Level 2.
   b. RTU-2: A portion of Level 2 and Level 3.

2. RTU-1 and RTU-2 utilize a variable air volume (VAV) control strategy incorporating variable speed drive motor controllers to modulate supply fan speed. During periods of low system demand, supply fans automatically reduce speed, minimizing fan horsepower and conserving electrical energy.
3. Supply air from RTU-1 and RTU-2 is transferred to their respective variable air volume (VAV) terminal units through a system of medium pressure ductwork. Each VAV terminal unit, equipped with a hydronic reheat coil, controls supply airflow rate (CFM) and temperature to maintain zone setpoint temperature.

4. Return air from RTU-1 and RTU-2 flows back to each roof top unit through above ceiling plenums and two return air shafts. Once inside the RTU, return air is either re-circulated through the building, or is relieved from the RTU through the relief air dampers.

B. Control the system to the following typical sequences:

1. VAV Motor Monitoring.
2. VAV Air-Handling Unit Fan Speed Control.
3. Minimum Motor Run Timer.
4. Air Filter Monitoring.
5. Smoke Detector Shutdown.
6. Fire Alarm System Interface.
7. Duct Static Pressure Monitoring and Shutdown.
8. Low temperature shutdown.
9. Zone VAV Temperature Control with Reheat.
10. Zone Temperature Monitoring.

C. Full Shutdown Mode:

1. Supply fan off.
2. Mixing box outdoor air damper and relief air damper shut.
3. Mixing box return air damper fully open.
4. Heating coil hydronic control valve modulating to maintain 55 degrees F. (adjustable) minimum mixing box air temperature.
5. Cooling coil off.

D. Occupied Mode (6 a.m. to 11 p.m., adjustable):

1. Control to the typical sequences.
2. Heating Coil (HC-1) control: Modulate the heating coil control valve to maintain a 55 degrees F supply air temperature (adjustable) whenever the outside air temperature is 55 degrees F or colder (adjustable) and Mixed Air Temperature is below 55 degrees F. Optimize the Supply Air Temperature (SAT) as follows:

    a. The optimum setpoint is a dynamic floating value of 55 degrees F. or more as required to satisfy the cooling demand of the critical zone.
    b. Definition: The critical zone is defined as that zone which requires the largest percentage of its zone terminal unit cooling capacity to maintain zone setpoint temperature.
    c. Find the critical zone by polling the condition status of each zone terminal unit and the demand for cooling from each zone thermostat. Ignore zone terminal unit serving storage rooms and similar small incidental spaces when searching for the critical zone.
    d. Dynamically optimize the SAT setpoint to the highest temperature possible (above 55 degrees F.) to satisfy the critical zone cooling requirement. Allow SAT to increase until the critical zone is operating with its zone terminal unit control damper at the 95 percent open position and zone setpoint temperature is being maintained within setpoint tolerance.

3. Cooling Coil (CC-1) control: Modulate the DX unit to maintain a 55 degrees F. supply air temperature (adjustable) during the cooling season whenever the outside air temperature is 57 degrees F. or warmer (adjustable) and the cooling system is enabled (through BAS).
4. Building Static Pressure Control: Modulate relief dampers to maintain RTU zone static pressure.

E. Unoccupied Mode (11 p.m. to 6 a.m., adjustable):

1. Air handling unit is initially operating in Occupied Mode.
2. The system operates the same as occupied mode, except:

a. Cooling coil control is disabled.
b. Outside air dampers are shut.

F. DX Cooling System:

1. On call for cooling by the cooling coil:

a. Maintain supply air temperature set point with packaged controls via the interface with the BAS.
b. Modulation of the cooling coil output shall be through the control system, either through an analog signal from the BAS or through an acceptable interface.
c. When cooling is satisfied, disable cooling coil.

G. Building Static Pressure Control:

1. Pressure Sensing:

a. Provide two outdoor ambient static pressure reference heads located above the roof line on opposing corners of the building.
b. Provide an indoor ambient static pressure reference head in the following general location. See drawings for specific sensor location:

1). Level 1 dental reception area.

c. Provide differential pressure analog signals to the BAS between the average of the 2 outdoor ambient static pressure reference heads and each indoor ambient static pressure reference head.

2. Relief Fan Operation:

a. Open lead relief fan damper and start lead relief fan. Increase relief fan speed to maintain negative 0.1” PSID differential pressure setpoint (adjustable) between the fan room and averaged outdoor ambient pressure.
b. If the lead relief fan speed increases to 100 percent and the differential pressure setpoint has not been reached, continue to start additional relief fans in series until setpoint is established. Modulate speed of last fan operating to maintain fan room differential pressure setpoint.
c. Monitor building zone differential pressure. Reset fan room differential pressure to maintain a slightly positive (0.05 inch W.C., adjustable) building pressure.

d. When ventilation system shifts to Unoccupied Mode, stop relief fans, and shut relief fan dampers. Disable Building Static Pressure Control sequence.
e. Rotate lead relief fan daily.

H. Maintenance and Alarm Monitoring:

1. See Typical Sequences.
2. RTU Flow monitoring:

a. Provide BAS monitoring of variable speed drive enable/disable contacts, analog speed controller, and trouble contacts.
b. Generate “VSD Fault” alarm if the VSD fan motor controller goes into fault.
c. Monitor fan motor and generate a fan specific “RTU-X off” critical alarm if RTU-X fails to operate.

3.4 VENTILATION SYSTEMS (RTU-2)

A. Existing sequences to remain.

3.5 NEW AIR TERMINAL UNITS AND ZONE TEMPERATURE CONTROLS

A. Project revises existing air terminal units and zone temperature controls on level 1 and level 2 areas of work. Match existing control sequences and add programming for unoccupied minimum air terminal unit airflow settings for new level 1 dental clinic zones and level 2 optometry clinic zones as noted on drawings.

3.6 NEW DENTAL GAS AND VACUUM SYSTEMS MONITORING

A. Project adds new dental compressed air, vacuum, and medical gas equipment. Match existing sequences for equipment trouble status monitoring via the BAS.

3.7 FIRE ALARM PANEL MONITORING – EXISTING SEQUENCE TO REMAIN, SEQUENCE PROVIDED FOR REFERENCE

A. Monitor the building fire alarm panel alarm (common alarm, common trouble, and common sprinkler alarm) conditions.

3.8 TYPICAL SEQUENCES

A. Setpoints and delays shall be adjustable. Delays shall be incorporated to prevent short cycles to account for system "inertia", equipment and control device operations, and control system sampling frequency for specified sequence of operations.

B. Equipment and system operating conditions used for control shall be field adjusted during testing, adjusting, and balancing, and field verified during commissioning.

C. Typical Circulating Pump Rotation:

1. For lead/standby and lead/lag pump systems, alternate lead pump monthly. Operate pumps with lead pump in "run" and standby (lag) pump in "standby."
2. If lead pump fails to start disable lead pump and start standby (lag) pump.

D. Typical Fan and Pump Constant Speed Motor Monitoring:

1. Monitor motor current and generate an independent maintenance alarm if fan fails when it has been commanded “On” by the BAS. Current type switches are not acceptable.
2. Determine normal and motor inrush currents. Set high and low alarm setpoints based upon normal operating currents. Provide a time delay to reduce nuisance alarms due to motor start inrush currents.
3. Generate a "<Unit tag> low current motor fault" alarm if the motor current falls below low alarm setpoint whenever the device has been commanded on.
4. Generate a "<Unit tag> high current motor fault" if the motor current is above high alarm setpoint whenever the device has been commanded on.
5. Points: See specific control sequence.

E. Typical Fan and Pump Variable Speed Drive (VSD) Motor Monitoring:

1. Monitor Variable Speed Drive (VSD) and alarm if the fan or pump or VSD fails when it has been commanded "On" by the BAS.
2. Set high and low alarm setpoints based upon VSD operating current parameters.
3. Generate a "<Unit tag> low current motor fault" alarm if the motor current falls below low alarm setpoint whenever the device has been commanded on.
4. Generate a "<Unit tag> high current motor fault" if the motor current is above high alarm setpoint whenever the device has been commanded on.
5. Limit speed when Emergency Generator is running. Refer to the Generator sequence of operations.

F. Typical Fan and Pump Variable Speed Drive (VSD) Motor Speed: Motor shall be set to run at minimum of 30 percent speed, unless noted otherwise.

G. Typical Minimum Motor Run Timer: Provide adjustable system run time of 10 minutes (minimum) and adjustable system off time of 5 minutes (minimum).

H. Typical VAV Air-Handling Unit Fan Speed Control:

1. Locate duct static pressure sensors in main supply air duct, approximately 3/4 the distance between the AHU supply outlet and most remote zone variable air volume (VAV) terminal unit branch duct connection. Suggested locations are shown on the drawings (two on level 1).
2. Compare branch duct pressure readings for each air handling system and control supply fan speed, through the variable speed drive (VSD) controller, to maintain the lowest branch pressure at 1.5-inch W.C. (adjustable) setpoint pressure.
3. Program VSD such that the air handling unit goes into Full Shutdown Mode in the event of VSD failure. Require manual position on VSD keypad to restart the system. The supply fan operates at 75 percent speed during manual mode.

I. Typical Safety Shutdowns:

1. "Hardwire" system safety shutdowns to provide safe, reliable operation in the event of Building Automation System (BAS) failure.
2. Where equipment is provided with packaged stand-alone controls, capable of operating the equipment independently from the BAS, provide control logic which shifts the equipment to stand-alone operation in the event of BAS failure.

J. Typical Smoke Detector Shutdown:

1. Provide smoke detector in the main return duct / at return air damper assembly immediately upstream of AHU cabinet for all air handling units larger than 2,000 CFM.
2. Hardwire supply-duct smoke detectors directly to the building's fire alarm panel. Refer to Section 28 31 00 – Addressable Fire Alarm for sequence of operation.
3. Provide fan starter with hardwire relay for smoke detector. Stop fan motor on smoke detection from smoke detector.
4. Provide BAS monitoring of smoke detector status. Generate "<Unit tag> Smoke Alarm" alarm on smoke detection and shut down fan as follows:

    a. Verify supply fan is off. If supply fan is still running, stop fan.
    b. Close outside air dampers and reposition return air damper to 100 percent open.

K. Typical Fire Alarm System Interface:

1. On "General Alarm" from fire alarm panel, the BAS shall:

    a. Verify air handling unit fans are off. If fans are operating, stop fans.
    b. Shut IAQ and economizer cooling dampers. Reposition return air damper to 100 percent open.
    c. Stop relief fans and shut relief fan dampers.
    d. Stop exhaust fans and shut exhaust fan dampers.
    e. Close relief air hoods.

L. Typical Duct Static Pressure Monitoring and Shutdown:

1. Duct Static Pressure Monitoring:

    a. Generate "<Unit tag> Duct Static Pressure High/Low" maintenance alarm if duct pressure falls outside setpoint tolerance, plus or minus 0.05 inches W.C.
    b. Provide three-minute alarm time delay (adjustable) to prevent spurious alarms.

2. If ventilating system duct supply static pressure increases to High Duct Static Pressure alarm point (3.0 inches W.C. adjustable):

    a. Command the applicable ventilating system to Full Shutdown Mode.
    b. Provide "<Unit tag> High Static Pressure" alarm.

3. Provide BAS software reset to reinitiate AHU ventilation system restart sequence.

M. Typical Low Temperature Shutdown:

1. Stop fan and close outside air damper if discharge supply temperature is less than 40 degrees F.

2. Provide “<Unit tag> Low Temperature” alarm to BAS.
3. Provide BAS software reset to initiate the system restart sequence.

N. Typical Air Filter Monitoring:

1. Provide differential pressure sensor across each filter bank. Provide high pressure alarms at set point (adjustable) as indicated in the sequences or as directed.
2. Pre-Filter Banks:

    a. Differential pressure range is 0.28 inches W.C. (clean) to 0.90 inches W.C. (dirty) at 500 feet per minute.
    b. Generate "<Unit tag> High Filter Differential Pressure" alarm at 0.80 inch W.C.

3. Final Filter Banks:

    a. Differential pressure range is 0.38 inches W.C. (clean) to 1.5 inches W.C. (dirty) at 300 feet per minute.
    b. Generate "<Unit tag> High Filter Differential Pressure" alarm at 1.30 inch W.C.

O. Typical Zone VAV Temperature Control with Reheat:

1. Zone Sensors: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.
2. Provide duct-mounted supply-air temperature sensors downstream of each reheat coil.
3. Occupied Mode Operation:

    a. Cooling Mode: Modulate the VAV terminal unit control damper between minimum CFM and maximum cooling CFM to maintain zone normal setpoint temperature plus or minus one degree F. Reheat coil control valves remain shut.
    b. Heating Mode: Modulate the VAV terminal unit control damper between minimum CFM and maximum heating CFM to maintain zone normal setpoint temperature plus or minus one degree F. Modulate VAV reheat coil control valve in parallel with control damper.
    c. Limit the discharge air temperature to 20 deg F greater than the room temperature.

4. Unoccupied Mode Operation:

    a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and maximum heating CFM to maintain zone setback temperature plus zero, minus three degrees F. Modulate VAV reheat coil control valve in parallel with control damper.
    b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

P. Typical Zone Temperature Monitoring:

1. Generate “<location> Zone Temperature High/Low” maintenance alarm if any zone temperature is not being maintained within setpoint band tolerance.

3.9 MECHANICAL ROOM VENTILATION SYSTEM

A. Existing sequence to remain.

3.10 TELECOMMUNICATIONS & ELECTRICAL ROOMS AIR-CONDITIONING SYSTEMS (AC-1/CU-1, AC-2/CU-2)

A. Operate air conditioning systems utilizing package microprocessor control systems. Monitor general fault alarm through BAS.

3.11 HYDRONIC HEATING SYSTEM OPERATION

A. General System Description:

1. The hydronic heating system consists of two identical condensing hydronic boilers (BLR-1 and BLR-2) each sized for approximately 60 percent of the building's and parking garage's design heating load.
2. Heating loop lead/standby pumps PMP-1/PMP-1A provide variable speed circulation to VAV box reheat coils, cabinet unit heaters, unit heaters, radiant ceiling panels, and fin tube throughout the facility. Each pump is sized to handle 100 percent system zone flow.
3. Water heater loop lead/standby circulation pumps PMP-2/PMP-2A provide heating glycol fluid to the domestic water heaters (WH-1, WH-2). Each pump is sized to handle 100 percent system flow.
4. Boiler circulation pumps PMP-3/PMP-3A provide circulation to each of the boilers.

B. Coordination with Packaged Boiler Controls:

1. Coordinate connection of the BAS to the packaged controller.
2. Provide boiler plant enable/disable control via the BAS. Boiler sequencing is controlled by the Aerco Boiler Control System (ACS).

C. Full Shutdown Mode (Initial conditions):

1. Both boilers off.
2. Heating pumps off (PMP-1/PMP-1A).
3. Water heater loop circulator pumps off (PMP-2/PMP-2A).
4. Boiler circulator pumps off (PMP-3/PMP-3A).

D. Operating Mode:

1. System Enable and Startup:

a. Enable heating system pumps to run.
b. Start lead loop circulator pump (PMP-1 or PMP-1A).
c. After loop flow has been established for 10 minutes, enable boiler operation via boiler controller (ACS).

2. Boiler and Pump Control:

   a. Boiler lead-lag and staging control is provided by the ACS.
   b. Provide lead/standby control for loop circulators (PMP-1/ PMP-1A). Alternate lead pump during the heating season. Operate pumps with lead pump in "run" and standby pump in "standby." If lead pump fails to start as determined by analog current sensor, disable lead pump and start standby pump.

3. Boiler Operation:

   a. Supply temperature is determined by the BAS and sent to the ACS.
   b. Hydronic heating system supply temperature is reset according to the following table.

Hydronic System Temperature Reset Schedule	
Outside Air Temperature	**Heating Loop Water Temperature Setpoint**
60 Degrees F.	120 Degrees F.
10 Degrees F.	160 Degrees F.

   c. Monitor facility heating zones:

      1). If any zone is in 100 percent heating and cannot maintain zone setpoint temperature, reset Hydronic System Supply Temperature Setpoint up 2 degrees every 15 minutes until zone's heating calculation stabilizes at 80 percent.
      2). Record final Hydronic System Supply Temperature Setpoint and outside air temperature. Adjust Hydronic System Supply Temperature Reset Schedule to new outside air temperature and Hydronic System Supply Temperature Setpoint (adaptive learning routine).

   d. Boilers fire under the control of the boiler on-board combustion management system to maintain remote header temperature setpoint.
   e. Sequencing of individual boilers within the boiler plant is controlled by the ACS.
   f. Flow through standby boilers is isolated from the system loop via 2-way motorized isolation valves controlled by boiler manufacturer's control panel.
   g. Connect boiler supply and return header temperature sensors to the ACS.
   h. Connect boiler supply and return header temperature sensors to the BAS.
   i. Connect ACS outside air temperature sensor to the panel for use in the building hydronic heating supply water temperature reset control.
   j. Establish original boiler reset schedule within the ACS. This schedule will be used by the ACS if communication with the BAS is lost. This schedule will not be reset by the BAS adaptive learning routine.

      1). Coordinate with boiler manufacturer’s representative and adjust setpoints and time constants in accordance with manufacturer’s recommendations.
      2). Coordinate with Section 23 5216 and connect the ACS to the BAS through the BAS interface furnished with the ACS.

k. Coordinate with boiler manufacturer's representative and adjust setpoints and time constants in accordance with manufacturer's recommendations.
l. Coordinate with Section 23 5216 and connect the ACS to the BAS through the BAS interface furnished with the ACS.

4. System Shutdown:

a. Initiate Full Shutdown Mode in the following events:

1). Manual "off" mode.
2). Low water cutoff shutdown of any boiler.

E. Variable Speed Hydronic Pump Control (PMP-1 and PMP-1A):

1. Provide and locate separate differential pressure sensors as indicated on the drawings (two sensors).
2. Adjust VSD controller output to modulate pump speed between 30 percent and 100 percent flow to maintain the lowest-reading differential pressure sensor at setpoint pressure. Initial pressure setpoint is 5 PSIG. Setpoint to be adjusted during Testing, Adjusting and Balancing.
3. In the event of VSD failure, enable and run standby pump.

F. Hydronic System Monitoring and Alarm:

1. Boiler safeguard alarms (BLR-1 and BLR-2): Generate a separate "BLR-X Flame Failure" alarm if any boiler is shut down by its flame safeguard control system.
2. Display Status and Alarms obtained through the ACS interface. Translate Fault Codes into English Language description of fault.

a. Header Temperature.
b. Outside Air Temperature.
c. Fire Rate Out.
d. Header Setpoint Temp.
e. Total Boilers Fired.
f. Fault/Message Code.
g. Lead Boiler Number.
h. Boiler 1 Status.
i. Boiler 2 Status.
j. Return Sensor Temperature.
k. Net Boiler 1 Outlet Temp.
l. Net Boiler 2 Outlet Temp.
m. Net Boiler 1 Code (Fault).
n. Net Boiler 2 Code (Fault).

3. Heating loop pump trouble alarms (PMP-1/PMP-1A):

a. Monitor current for each pump through VSD. Refer to Typical VSD sequence.
b. Generate an alarm if pumps fail to operate in their normal sequence, i.e. alarm if:

1). Both pumps are off when system is in operating mode.
2). Lead pump fails to operate and system switches to standby pump.

3). Both pumps are running.

4. Heating water temperature alarm: Generate an alarm if heating water supply temperature is not maintained within 5 degrees F (adjustable; averaged over a 15 minute period).
5. Hydronic system low pressure alarm:

a. Monitor both the heating loop and the glycol heating loop systems pressures with analog sensor pressure sensors.
b. Generate a separate low-pressure alarm if any system pressure falls below 10 PSIG.

G. Domestic Water Heating Loop System (PMP-2/PMP-2A):

1. General System Description:

a. System provides heated glycol to the indirect water heater heating coils.
b. System consists of variable speed pumps (PMP-2/PMP-2A) with each sized for 100 percent of system flow through the water heaters. Lead/standby pumps PMP-2/PMP-2A circulate heated glycol through the indirect water heater heating coils.

2. System Shutdown (Initial conditions):

a. System circulator pumps off (PMP-2/PMP-2A).
b. Refer to Hydronic System Full Shutdown Mode.

3. Operating Mode:

a. Normal system operation:

1). Variable speed glycol circulation pumps (PMP-2/PMP-2A):

a) Enable lead pump when an WH is operating and calls for heat.
b) Adjust ECM controller output to modulate pump speed between 30 percent and 100 percent flow to maintain the water heater setpoint. Initial differential pressure 5 PSIG.
c) In the event of ECM failure, switch to the standby pump.

4. Monitoring and Alarms:

a. Pump trouble alarms (PMP-2/PMP-2A).

1). Monitor current for each pump through the ECM.
2). Generate an alarm if pumps fail to operate in their normal sequence, i.e. alarm if:

a) Both pumps are off when system is in operating mode.
b) Lead pump fails to operate and system switches to standby pump.
c) Both pumps are running.

3.12 SNOWMELT SYSTEM

A. Existing sequence to remain.

3.13 HYDRONIC HEATING SYSTEM DEVICES

A. Air Handler Heating Coils (RTU-1 and RTU-2): See ventilation system control sequences.

B. Zone VAV Terminal Reheat Coils (RTU-1): See ventilation system control sequences.

C. Zone VAV Terminal Reheat Coils (RTU-2): Existing ventilation system control sequences to remain.

D. Hydronic Unit Heaters:

1. At 60 degrees F. (adjustable) and decreasing, start recirculating fan and open two-way hydronic control valve.
2. At 62 degrees F. (adjustable) and increasing, stop recirculating fan and shut two-way hydronic control valve.

E. Radiant Ceiling Panels:

1. At 68 degrees F. (adjustable) and decreasing, open two-way hydronic control valve.
2. At 70 degrees F. (adjustable) and increasing, shut two-way hydronic control valve.

3.14 PLUMBING

A. Domestic Hot Water Circulation Pump (PMP-4):

1. Turn pump on at 6 a.m. (adjustable).
2. Turn pump off at 9 p.m. (adjustable).
3. Monitor status of circulator pump and generate a pump specific alarm if the pump fails to operate in its normal sequence.

B. Domestic Water Heater (WH-1 and WH-2).

1. Utilize packaged water heater controls.
2. Set aquastat to 140 degrees F. (adjustable).

C. Industrial Water Heater and Circulation Pump (WH-3 and PMP-9).

1. Utilize packaged water heater controls.
2. Set aquastat to 125 degrees F. (adjustable).
3. Operate pump based on in-line aquastat, set to energize pump at 118 degrees F. (adjustable) and deenergize pump at 124 degrees F. (adjustable).
4. Monitor status of circulator pump and generate a pump specific alarm if the pump fails to operate in its normal sequence.

END OF SECTION 259000

PART 1 - GENERAL

1.1 SUMMARY

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

B. This section describes specific requirements, products, and methods of execution, which are typical throughout the electrical work of this project. Additional requirements for the specific systems may modify these requirements.

C. This Section applies to all Divisions 26, 27 and 28 and is part of all other Divisions 26, 27 and 28 Sections.

D. Index of Electrical Specifications:

1. 260000 - Electrical General Requirements
2. 260519 - Low Voltage Electrical Power Conductors and Cables
3. 260526 - Grounding and Bonding for Electrical Systems
4. 260529 - Hangers and Supports for Electrical Systems
5. 260533 - Raceway and Boxes for Electrical Systems
6. 260553 - Identification for Electrical Systems
7. 260943 - Network Lighting Controls
8. 262726 - Wiring Devices
9. 262800 - Low Voltage Circuit Protective Devices
10. 262816 - Enclosed Switches and Circuit Breakers
11. 262900 - Low Voltage Controllers
12. 265000 - Lighting Fixtures
13. 272010 - Telecom Distribution System
14. 281300 - Security Access System
15. 283100 - Addressable Fire Alarm System

1.2 REFERENCES

A. Codes: Perform work in strict accordance with applicable national, state and local codes; including, but not limited to the latest legally enacted editions of the following specifically noted requirements:

1. NFPA 70, National Electrical Code - NEC.
2. ANSI-C2, National Electrical Safety Code - NESC.
3. International Building Code - IBC.
4. International Fire Code - IFC.
5. Underwriters Laboratory (UL) or approved equal.

B. Standards: Reference to the following standards infers that installation, equipment and material shall be within the limits for which it was designed, tested and approved, in conformance with the current publications and standards of the following organizations:

1. American National Standards Institute - ANSI.
2. American Society for Testing and Materials - ASTM.
3. American Society of Heating Refrigerating and Air Conditioning Engineers - ASHRAE.
4. Institute of Electrical and Electronics Engineers - IEEE.
5. Insulated Cable Engineers Association - ICEA.
6. National Electrical Manufacturers' Association - NEMA.
7. National Fire Protection Association - NFPA.

1.3 DEFINITIONS

A. "Accessible" means arranged so that an appropriately dressed man, 6 feet-2 inches tall, weighing 250 pounds, may approach the area in question with the tools and products necessary for the work intended and may then position himself to properly and safely perform the task to be accomplished, without disassembly or damage to the surrounding installation.

B. “Authority Having Jurisdiction” is the individual official, board, department, or agency established and authorized by the political subdivision created by law to administer and enforce the provisions of the Code as adopted or amended.

C. "As Specified" denotes a product, system, or installation that:

1. Includes all of the salient characteristics identified in the Drawings and Specifications;
2. Meets all of the requirements of the "Basis of Design"; and
3. Is produced by a manufacturer listed as acceptable on the Drawings or in the Specifications.

D. "Basis of Design" refers to products around which the design was prepared. Some or all of the particular characteristics of Basis of Design products may be critical to the fit or performance of the completed installation. Such characteristics are often subtle. Where substitutions are made to products that are the Basis of Design, the Contractor is alerted that nominally acceptable substitutions may produce undesirable side effects such as switchboards that no longer fit the space due to increased product dimensions. The Contractor is responsible for resolving all impacts of substitutions. Approval of a substitution request does not relieve the Contractor of complying with the design intent and all Codes.

E. "Contracting Agency" is the Owner as defined in the General Conditions of the Contract.

F. “Demolish” means to permanently remove a component, equipment, or system and it's appurtenances with no intent for reuse and to properly dispose of it.

G. "Furnish" means to purchase material as shown and specified, and cart the material to an approved location at the site or elsewhere as noted or agreed to be installed by supporting crafts.

H. "Install" means to set in place and connect, ready for use and in complete and properly operating finished condition, material that has been furnished.

I. “Product” is a generic term that includes materials, equipment, fixtures and any physical item used on the project.

J. "Provide" means furnish all products, labor, subcontracts, and appurtenances required and install to a complete and properly operating, finished condition.

K. “Remove” means to remove a component, equipment, or system and it's appurtenances and either store it for re-installation, reuse, or turn it over to the Contracting Agency.

L. "Rough-in and Connect" means provide an appropriate system connection such as conduit with junction boxes, wiring, switches, disconnects, etc., and wiring connections. Equipment furnished is received, uncrated, assembled, and set in place under the Division in which it is specified.

M. "Serviceable" means arranged so that the component or product in question may be properly removed, and replaced without disassembly, destruction or damage to the surrounding installation. "Serviceable" components shall be "accessible".

N. "Shop Drawings" are dimensioned working construction drawings drawn to scale to show an entire area of work in sufficient detail to demonstrate service and maintenance clearances and complete coordination of all trades.

O. "Substitution" is a product, system or installation that is not by a listed manufacturer or does not conform to all salient characteristics identified in the Contract Documents, but which the Contractor warrants meets all specific requirements listed in the Contract Documents.

P. "System Drawing" is a diagrammatic engineered drawing that shows the interconnection and relationship between products to demonstrate how the products interact to accomplish the function intended. Examples of system drawings include control and instrumentation diagrams, and wiring diagrams. Some drawings, such as dimensioned and complete Fire Suppression Drawings may be both System Drawings and Shop Drawings.

1.4 CONSTRUCTION PHASING REQUIREMENTS

A. The facility will remain operational throughout the project construction. Project will require construction phasing to minimize impacts to facility operations. Contractor will be required to develop and coordinate construction phasing plans with Owner. Refer to Architectural and Division 1 for additional information.

1.5 PERFORMANCE REQUIREMENTS

A. Provide labor, products and services required for the complete installation, checkout and startup of electrical systems shown and specified. Where the work of several crafts is involved, coordinate related work to provide each system in complete and in proper operating order.

B. Lay out the work in advance and avoid conflict with other work in progress. Physical dimensions shall be determined from existing conditions. Verify locations for junction boxes; disconnect switches, stub-ups, etc., for connection to equipment furnished by others, or in other Divisions of this Work.

C. Refer to the "Suggested Coordination Schedule" in Section 200000 - Mechanical General Requirements.

D. Cooperate with others involved in the project, with due regard to their work, to promote rapid completion of the entire project.

E. Coordinate installation of panels, equipment, system components, and other products to provide proper service areas and access for items requiring periodic maintenance inspection or replacement.

F. Reference to a specific manufacturer's product (even as "Basis of Design") does not necessarily establish acceptability of that product without regard to compliance with all other provisions of these specifications.

G. Local Conditions: The Contractor shall thoroughly familiarize himself with the work as well as the local conditions under which the work is to be performed. Schedule work with regard to seasons, weather, climatic conditions and other local conditions which may affect the progress and quality of the work.

H. Demolition: Coordinate related demolition in support of the project. Restore circuits and systems, which are to remain, but which are affected in any way by demolition Work. Conduct a site visit prior to bid to determine Scope. Refer to Part 3 of this Section for execution requirements.

1.6 SUBMITTALS

A. Refer to Division 1 for general submittal, closeout submittal and product substitution requirements. In addition, prepare Divisions 26, 27 and 28 submittals in accordance with the following.

B. Specification section drawings, calculations, and products shall be complete and submitted together in one package.

C. General:

1. The Contracting Agency's obligation to review submittals and to return them in a timely manner is conditioned upon the prior review and approval of the submittals by the Contractor as required by the Construction Contract.
2. Streamlining: in many instances, the products, reference standards, and other itemized specifications have been listed without verbiage. In these cases, it is implied that the Contractor shall provide the products and perform in accordance with the references listed.
3. Submittal review is for general design and arrangement only and does not relieve the Contractor from any of the requirements of the Contract Documents.
4. Submittals will not be checked for quantity.
5. Submittals will not be exhaustively checked for dimension or fit, or for proper technical design of manufactured equipment. Provision of a complete and satisfactory working installation is the responsibility of the Contractor.

6. Furnish suppliers with the applicable portions of the Contract Documents and review and verify that the suppliers' submittals clearly represent products which comply with the Contract Documents.

D. Electronic Submittals:

1. Submittals may be in electronic (PDF) format.

a. Electronic submittals shall follow the organization and formatting required for paper submittals.

1). Provide electronic bookmarks within the PDF document in place of tabs and sub-tabs.
2). If individual PDF files are provided for each product or shop drawing sheet, organize files into folders and name files and folders to correspond with applicable specification sections or drawing titles.

b. If submittal is a scanned document, run the optical character recognition OCR function to ensure the document is searchable and can be copied and pasted.
c. Electronic submittals may be transmitted via Email, disc or download from a project or construction Website.

E. Coordination:

1. Create and maintain a master submittal log for all items submitted in Divisions 26, 27 and 28.
2. Prior to submission for approval hold a meeting of all trades to review all shop drawings and submittals. All trades shall cross-check all shop drawings and submittals for conflicts, clearances, physical space allocation and routing, discrepancies, dimensional errors, omissions, contradictions, departures from the Contract requirements, correct electrical/mechanical services and connections, and provisions for commissioning.
3. Revise, correct, and appropriately annotate submittals prior to submission for approval.
4. A current copy of approved submittals and the submittal log shall be kept at the job site.

F. Product Submittals

1. General: This section describes in detail the preparation of electrical product submittals. Submittals not provided as described shall be rejected without review. This procedure is designed to accelerate and improve the accuracy of the technical review process, as well as, simplify the preparation of the Installation, Operation, and Maintenance Manuals (IO&Ms) during project closeout.

2. Submittal Organization:

a. Organize product submittal information in the same order as the products are specified to simplify the technical review process. Provide a separate tabbed divider for each Divisions 26, 27 and 28 specification section. Provide the typed section number on each tab.
b. Within each section, organize the product information in the same order as the products are specified in Part 2 of each applicable specification section. Provide sub-

tabs within each section for each separate product article. Provide the typed product article number on each tab.

c. Provide product submittal information for each product specified in 8-1/2" x 11" format. Fold-out 11" x 17" format is also acceptable.

d. If a particular specified product is being omitted from the product submittal or will not be used for the project, provide a single sheet within the article tab identifying the product and annotated with a brief reason why the product is not being submitted, for example: "NOT USED," NO SUBMITTAL REQUIRED," "TO BE SUBMITTED BY (PROVIDE DATE)," etc. This will inform the reviewer that the product was not overlooked.

e. Partial submittals from individual subcontractors may be provided which cover a particular sub-contractor's scope of work. In this case, arrange partial submittals by system classification such as: LIGHTING, POWER DISTRIBUTION, FIRE ALARM, ACCESS CONTROL SYSTEM, etc. Within each system classification, arrange product submittals by specification section, as described, such that each specification section can easily be reorganized into a master set of Divisions 26, 27 and 28 product submittals organized by specification section. This will greatly simplify the preparation of IO&M manuals as described below.

f. Bind product submittal information in 3 inch wide, hard backed, loose leaf, 3 ring binders with clear front and spine insert pockets. Divide information into multiple volumes such that the pages in each binder rest naturally on one side of rings.

g. Provide a master table of contents at the front of each volume which lists the Divisions 26, 27 and 28 specification sections and indicates which sections are located within each volume.

h. Provide a table of contents within each section which lists the Part 2 products for that section in the same order as the applicable specification section.

i. Provide identical cover and spine inserts for each product submittal volume.

j. For multiple volumes, label each volume. Include the following typed information on the front cover and spine inserts of each volume:

1). The Contracting Agency Name
2). Project Name
3). Contractor Name
4). Subcontractor Name preparing the submittal.
5). Date that the submittal or resubmittal was initiated.
6). "Electrical Product Submittals", etc. as appropriate.
7). "Volume 1 of X, Volume 2 of X," etc.

3. Product Information:

a. Indicate manufacturer's name and address, and local supplier's name, address, phone number.

b. Indicate each product as "Basis of Design", "As Specified" or as "Proposed Substitution."

c. Identify Catalog designation and/or model number.

d. Neatly annotate each salient characteristic and design options of the product to demonstrate compliance with the Contract Documents to include: Scheduled information, drawing information and specified information. Clearly indicate product deviations from the Contract Documents and mark out non-applicable items on generic "cut-sheets."

e. Include manufacturer provided dimensioned equipment drawings with mechanical and electrical rough-in connections.
f. Include operation characteristics, performance curves and rated capacities.
g. Include motor characteristics and wiring diagrams for the specific system.
h. Provide basic manufacturer's installation instructions.

4. Provide coordination data to check protective devices.
5. Provide information required to verify compliance with the short circuit withstand and interrupting ratings, as shown on the Drawings or further stated in these Specifications.
6. Provide certification that all data shown on the Drawings or further stated in these Specifications concerning available short-circuit currents has been confirmed with the serving Electric Utility.
7. Product Substitutions:

a. Clearly indicate both in the section table of contents and on the individual product submittal information each proposed substitution, deviation or change from the product as described in the Contract Documents.
b. Submittal approval does not include substitutions, deviations or changes from the requirements of the Contract Documents unless they are specifically itemized and approved. The term "No Exceptions Taken" will not apply to substitutions, deviations or changes not clearly identified.
c. Provision of a satisfactory working installation of equal quality to the system as described in the Contract Documents shall be the responsibility of the Contractor.
d. Correct unapproved deviations from the Contract Documents discovered in the field as directed by the Contracting Agency at no additional cost to the Owner.

G. System Drawings:

1. Submit System Drawings for dynamic elements/systems of the project which are performance specified to include but not limited to: Fire Alarm Systems, Lightning Protection Systems and stand-alone packaged equipment.
2. Prepare system drawings on full sized sheets of the same size as the original construction drawings.
3. Include with each system a sequence of operation narrative which describes each mode of system operation in sufficient detail to demonstrate compliance with the Contract Documents to the satisfaction of the Contracting Agency.

H. Shop Drawings:

1. General:

a. The Contract Documents are not intended for nor are they suitable for use as shop drawings. Do not use Contract Drawings for direct fabrication or installation of products or equipment.
b. Divisions 26, 27 and 28 products and systems shall not be installed without shop drawings approved by the Contracting Agency.
c. Rework, changes or additional engineering support required as a result of the installation of products and systems prior to the approval of applicable shop drawings by the Contracting Agency shall be provided at the Contractor's expense.

2. Preparation:

   a. Review each Divisions 26, 27 and 28 specification section and identify the project's shop drawing requirements.
   b. Prepare shop drawings on full sized sheets of the same size as the original construction drawings.
   c. Arrange shop drawings to scale, showing dimensions where accuracy of location is necessary for coordination or communication purposes.
   d. Incorporate the actual dimensions and configurations of the products and systems approved through the product submittal process into the shop drawings.
   e. Provide dimensioned maintenance clearance areas around each product as recommended by the manufacturer.
   f. Meet with and coordinate Divisions 26, 27 and 28 work with the interrelated work of other trades including Architectural, Civil, Structural, and Mechanical to identify and resolve potential conflicts.
   g. Clearly identify and provide recommendations to resolve major conflicts which may impact the design of the systems as shown. Resolve such conflicts during the shop drawing review process.
   h. In cases where one or more equipment items in a mechanical or electrical room or space differ in dimensions or configuration from Basis of Design equipment, the working drawing shall show the entire area. The drawing shall be dimensioned to indicate that required aisle ways and maintenance clearances are being maintained to at least the degree shown on the Contract Drawings.
   i. Provide shop drawings for all products, systems, system components, and special supports that are not a standard catalog product and which may be fabricated for the Contractor or by the Contractor. In addition provide shop drawings for:

      1). Electrical and telecommunications rooms and spaces, including all equipment. Demonstrate all required clearances and working spaces are provided.
      2). Routing and interdisciplinary coordination of groups of conduits numbering more than one and over two inch trade size.
      3). Cable Trays.
      4). Telecom equipment rack elevations.
      5). Where noted on the drawings.
      6). Where noted in other Divisions 26, 27 and 28 sections.

3. Shop Drawing Submittal:

   a. Submit dimensioned shop drawings as specified to demonstrate proper planning and sequencing of the applicable trades for the installation and arrangement of Divisions 26, 27 and 28 with respect to other interrelated work.
   b. Installation conflicts arising from the failure to properly coordinate the work of related trades shall be resolved at the Contractor's expense.

I. Record Drawings

1. General: As the Work progresses, neatly annotate a designated and otherwise unused, set of Divisions 26, 27 and 28 Contract Drawings to show the actual locations and routing of Divisions 26, 27 and 28 Work and the terminal connection points to related Work. As a minimum, include the following:

a. Annotate record drawings to incorporate each applicable addendum.
b. Annotate record drawings as directed by each applicable Request for Information (RFI) and accepted Change Order Proposal.
c. Modify record drawings to show actual equipment sizes and locations.
d. Provide fully dimensioned locations for permanently concealed conduits (i.e. conduit cast in concrete or buried underground/underslab).
e. Show routing of work in permanently concealed blind spaces within the building.
f. Maintain drawings in an up-to-date fashion in conjunction with the actual progress of installation. Accurate progress mark-ups shall be available on-site for examination by the Contracting Agency or their representative at all times.

2. Preparation:

a. Neatly annotate record drawings to provide clear interpretation to support electronic drafting by a third party.
b. Tape electronic sketches from addendums and/or RFIs directly to the record drawings as overlays.
c. Annotate the record drawings in colored pencil using the same symbols and abbreviations as indicated in the Divisions 26, 27 and 28 legends and schedules of the Contract Drawings.

1). Red to add information.
2). Green to delete information.
3). Blue to provide additional clarifying information which is not to be drafted.

d. After submittal to the Contracting Agency, provide additional clarification, information or rework as necessary to support the accurate interpretation and electronic drafting of the record drawings.

3. Submittals:

a. Provide dimensioned underslab record drawings to the Contracting Agency prior to pouring the slab. For slabs poured in multiple sections, provide record drawings for the applicable slab sections to the Contracting Agency prior to each pour.
b. Provide complete record drawings for concealed areas (i.e. above lay-in and hard ceilings and inside walls) to the Contracting Agency prior to concealment.
c. Provide the remaining portion of the record drawings for exposed areas to the Contracting Agency prior to the final completion of the project.
d. Prepare wiring diagrams for individual special systems as installed. Identify components and show wire and terminal numbers and connections. Include diagrams from the shop drawings and submittals, updated to show as-built condition.

J. Test Certificates:

1. Review the submittal requirements for Quality Assurance/Control Submittals for each specification section.
2. Submit copies of design data, test reports, certificates, manufacturer's instructions and field test reports as specified. This information may be included within the Operations and Maintenance (IO&M) Manuals as determined by the Contracting Agency.