ADDENDUM NO. 01 **Date: APRIL 27, 2026**
To Drawings and Specifications dated 03/17/2026

PROJECT: **Willmore ES HVAC Upgrade & Modernization**
A#04-124971
Westminster School District

PROJECT LOCATION: 7122 Maple St
Westminster, CA 92683

PROJECT ARCHITECT PBK Architects
2400 E. Katella Ave., Ste 950
Anaheim, CA 92806

This Addendum forms a part of the Contract Documents. It modifies the original Project Manual and Drawings, as well as any Addendum previously issued, as noted below. Bidders are required to acknowledge receipt of this Addendum in the space provided in the proposal form. Failure to acknowledge receipt of each addendum may subject bidder to disqualification.

SPECIFICATIONS:

Item No. 1-01: **23 00 01** **HEATING VENTILATING & AC**

1. Revised Section 2.6.B - Variable Refrigerant Flow Air Conditioning Specification – Heat pump.

Item No. 1-02: **23 09 23** **DIRECT DIGITAL CONTROLS**

2. Added section Part 1 – 1.0 – Owner Furnished Contractor Installed (OFCI) Equipment

Item No. 1-03: **26 20 00** **ELECTRICAL DISTRIBUTION EQUIPMENT**

3. Added section Part 1 – 1.0 – Owner Furnished Contractor Installed

DRAWINGS:

Item No. 1-04: **M5.01** **MECHANICAL SCHEDULES**

4. Added additional notes to schedules.

Item No. 1-05: **E0.01** **ELECTRICAL SITE PLAN**

5. Detail – Keyed Notes
    a. Added keynote [9] – “Equipment to be OFCI (Owner Furnished, Contractor Installed.”

6. Detail 1 – Electrical Site Plan
    a. Added keynote [9] to Main Switch Board ‘MSB’.

Item No. 1-06: **E5.01** **SINGLE LINE DIAGRAM & SCHEDULE**

7. Detail – Keyed Notes
    a. Added keynote [4] - “Equipment to be OFCI (Owner Furnish, Contractor Installed.”

8. Detail 2 – Single Line Diagram - Renovation
    a. Added keynote [4] diagram & schedule

END OF ADDENDUM 01

SECTION 23 00 01 - HEATING, VENTILATING AND AIR CONDITIONING

PART 1 GENERAL

1.1 GENERAL CONDITIONS

A. The foregoing Section 23 00 00, General Mechanical Provisions shall form a part of this specification.

1.2 SCOPE

A. Included: Perform all work necessary and required to complete construction as indicated. Such work includes the furnishings of all labor, materials, and services necessary for a complete, lawful, and operating air conditioning, heating, ventilating system with all equipment as shown or noted on the drawings or as specified herein. The work includes, but is not necessarily limited to, the following:
   1. Heating, ventilating and air conditioning equipment.
   2. Air distribution system (Ductwork, Air Terminals, etc.).
   3. System insulation.
   4. Controls and control wiring and conduit for control wiring.

B. Work Specified Elsewhere:
   1. Line voltage power wiring (60 volts or greater), motor starters in motor control centers, and disconnect switches are included in the electrical section.
   2. Connection of gas and condensate drains to equipment.
   3. Access doors.

PART 2 MATERIALS

2.1 DUCTWORK MATERIALS

A. General: All ductwork materials shall have fire and smoke hazard ratings as tested under ASTM E-84 and UL-181 not exceeding a flame spread of 25 and smoke developed of 50. All ductwork shall be per Chapter 6 of the CMC.

B. Low Velocity Metal Ductwork: Metal ductwork shall be galvanized sheet steel, ASTM A653.

C. Low Velocity Flexible Ductwork: Insulated flexible ductwork. Continuous internal liner bonded to galvanized steel wire helix. One pound per cubic foot glass fiber insulation, R-8. Thermal conductivity shall not exceed 0.13 Btu/hr. sq. ft.- degrees F at a mean temperature of 75°F. Seamless vapor barrier jacket. Each length shall have a factory installed metal sleeve at each end. Duct shall be capable of continuous operation at 1.5" of water static pressure and 4000 ft./ min. air velocity. Maximum length 5 ft., single piece at runouts to air terminals. Genflex, Lamborn or equal.

D. Spiral Duct: Ductwork shall be galvanized steel with uni-seal spiral seamlock and uni-seal fittings, ASTM A653. United McGill Corp or equal. All exposed spiral duct shall be painted, color selected by Owner.

E. Bonding Adhesive: Durodyne WBG, Scotchgrip Adhesive 4230 or equal.

F. Duct Mastic: Minnesota Mining and Manufacturing Duct Sealer 800, Tuff-Bond No. 12, Glencoat Seal-Flex or equal.

G. Duct Joints:
1. As an option to joints and seams designated by SMACNA or shown on Drawings, the following systems may be used:
   a. Ducts with sides 24 inches to 48 inches, transverse duct joint system by Ductmate Jr., Nexus or equal (SMACNA "E" Type connection).
   b. Ducts 48 inches and larger, Ductmate Regular, Nexus (SMACNA "J" Type connection) or equal.

H. Fiber Tape: Mineral impregnated fiber tape and plastic activator-adhesive. Hardcast, Inc., United McGill Uni-Cast or equal.

2.2 AIR TERMINALS AND DUCT FITTINGS

A. Grilles: (Grilles, Registers and Diffusers)
1. Information on Drawings: Refer to the Air Distribution Schedule on the drawings for the list of grilles. Manufacturer's model numbers are listed to complete the description. Equivalent models of J & J, Krueger, Barber-Colman, Anemostat, Price, Titus or equal. Refer to the floor plans for neck size, CFM, air diffusion pattern, and fire damper, if required.
2. Performance: If, according to the certified data of the manufacturer of the proposed units, the sizes indicated on the drawings will not perform satisfactorily, the units shall be re-selected by the Contractor for the proper diffusion, spread, drop, and throw.
3. Frame and Accessories: All supply, return, and exhaust grilles shall be provided with cushion heads and attachments to structure, unless otherwise noted. All surface mounted grilles shall have a perimeter gasket and flanged edge. All grilles shall have frames suitable for mounting in the surfaces designated by the architectural drawing, coordinate prior to ordering.
4. Finish: All ceilings and wall grilles shall have a paintable white finish unless otherwise noted. Interior components shall be flat black.
5. Gyms: Provide 12 Ga. wire safety cables for all overhead grilles in Gym.

B. Turning Vanes: Double wall, hollow metal, air-foil shape. Spacing in accordance with manufacturer's recommendations. Aero Dyne, HEP or equal.

C. Flexible Connection: UL listed neoprene coated 30-ounce fiberglass cloth. 3" metal, 6" fabric, 3" metal. Ventglas or equal.

D. Branch Duct Volume Damper: Volume control damper (VCD) in rectangular ducts shall be as follows: Opposed blade, 6” maximum blade width, 16-gage blade, 48” maximum length, nylon or oil impregnated bronze bearings, ½” diameter pin shaft, 16-gage channel frame, actuating rod and linkage out of air stream. VCD in round duct shall be as follows: Damper blade full height of branch and 1” less than branch width. All branch dampers shall have regulator with stamped steel handle, spring loaded shaft nut, cast body, and serrated self-locking die cast core. Regulator for horizontal ducts overhead shall be mounted on sides or bottom of ducts. Secure a 12” length of brightly colored plastic ribbon to handle for ease of location. Where rectangular or round ductwork is insulated, slit insulation to allow handle to protrude. Ventlok 641 (with 607 end bearing for round ducts).

E. Fire/ Smoke Damper: Multi-blade construction in accordance with CBC & CMC. UL 555 and UL 555S labels. Blades shall have metal-to-metal seals and not rely on actuator torque to maintain leakage rating. Prefco, Air Balance, Ruskin, Greenheck 5020-1 with 5800MB2 power open/spring close operator, or equal.

2.3 DUCTWORK INSULATION MATERIALS

A. General: All ductwork insulation materials shall have fire and smoke hazard ratings as tested under ASTM E-84 and UL-181 not exceeding a flame spread of 25 and smoke developed of 50.

B. Acoustic Lining: Glass fiber. One side coated to prevent fiber erosion up to 6000 ft./ min. Average noise reduction coefficient of 0.90. 0.13 Btu/ hr – sq. ft. – degrees F conductivity at a mean temperature of 75 degrees F, R-8. CSG Insulation Corp., Schuller, Owens-Corning, Knauf or equal. Duct dimensions shown on drawings for lined duct are clear (net) opening inside of lining.

C. Fiber Glass Blanket: Foil faced, 0.13 Btu/ hr – sq. ft. – degrees F conductivity at a mean temperature of 75 degrees F, R-8. CSG Insulation Corp., Schuller, Owens-Corning, Knauf or equal.

D. Bonding Adhesive: Benjamin Foster 85-15 or equal.

2.4 PIPING MATERIALS

A. Refrigerant Piping:
1. Type L hard temper seamless copper, ASTM B88. Wrought copper fittings ANSI B16.22. 95/ 5 tin-silver brazed joints. Provide schedule 40 PVC sleeve pipe for all below grade refrigerant piping. All piping shall be sized per equipment manufacturer requirements.
2. Valves and Specialties:
   a. Line Valves: Bronze body, ball type, TFE locked in seals. Back seated valve stem. Contromatics C-11.
   b. Filter-Drier: Replaceable core. Capacity in accordance with ARI Standard 710. Sporlan "Catch-All".
   c. Moisture Indicator-Sight Glass: Double port. Henry, Sporlan.
   d. Vibration Isolating Connection: Seamless flexible bronze tubing, braid covered. Suitable for system pressure. American, Flexonics.

B. Refrigerant Piping (Ductless Split System Multi-Zone):
1. Type ACR soft temper seamless copper, ASTM B280. Cast copper alloy fittings for flared copper tubes, ASME B16.26. Follow the Society of Automotive Engineers SAE J533 Standard-Flares for tubing. All piping shall be sized per equipment manufacturer requirements.
2. Valves and Specialties:
   a. Line Valves: Bronze body, ball type, TFE locked in seals. Back seated valve stem. Contromatics C-11.
   b. Filter-Drier: Replaceable core. Capacity in accordance with ARI Standard 710. Sporlan "Catch-All".
   c. Moisture Indicator-Sight Glass: Double port. Henry, Sporlan.
   d. Vibration Isolating Connection: Seamless flexible bronze tubing, braid covered. Suitable for system pressure. American, Flexonics.

C. Miscellaneous Piping Items:
1. Pipe Support:
   a. Pipe Hanger: Adjustable split ring, swivel hanger and rod. Black malleable iron. Size and maximum loads per manufacturer's recommendation. Felt Lined, Kin-Line 450 F.
   b. Construction Channel: 12 gage 1-5/8" x 1-5/8" steel channel. Single or multiple sections. Self-locking nuts and fittings. Kin-Line, Unistrut.
2. Pipe Sleeves: 24 gage galvanized steel. Adjus-to-Crete #10 with #99 thimble for floors. #100 for walls.

D. Flashing: Flashing for piping through roof shall be prefabricated 24 gage galvanized steel roof jacks with 8" square flange around pipe. Seal with weatherproofing mastic.

2.5 PIPING INSULATION MATERIALS

A. General: All piping insulation materials shall have fire and smoke hazard ratings as tested under ASTM E-84 and UL 723 not exceeding a flame spread of 25 and smoke developed of 50.

B. Refrigerant Piping: Rubber based elastomeric preformed pipe insulation. Thermal conductivity shall not exceed 0.25 Btu-in/hr-SF-degree F at mean temperature of 75 degrees F., 3/4" thick. Provide aluminum pipe and fitting jacketing. 0.016" thickness for straight pipe, 0.024" thickness for fittings with integral moisture barrier, pre-fabricated strapping and seals for piping exposed to weather, Childers, Pabco or equal.
1. Insulation shall be provided on both refrigerant lines for ductless split systems.

2.6 EQUIPMENT

A. General Requirements:
1. Capacity: Capacities shall be in accordance with schedules shown on drawings. Capacities are to be considered minimum.
2. Dimensions: Equipment must conform to space requirements and limitations as indicated on drawings and as required for operation and maintenance. Where Architectural screening is indicated, equipment shall not extend above or beyond screening. Equipment will not be accepted that does not readily conform to space conditions. Prepare and submit layout drawings for all proposed equipment (different than scheduled units) showing actual job conditions, required clearances for proper operation, maintenance, etc.
3. Ratings:
   a. Gas: Gas burning equipment shall be furnished with 100% safety gas shut-off, intermittent pilot ignition, and be CSA (US) certified, except that boilers shall be CSA (US) certified or UL listed.
   b. Electrical: Electrical equipment shall be in accordance with NEMA Standards and UL or ETL listed where applicable standards have been established.
4. Piping: Each item or assembly of items shall be furnished completely piped for connection to services. Control valves and devices shall be provided. Equipment requiring domestic water for non-potable use shall be provided with backflow preventer acceptable for intended use by local governing authorities.
5. Electrical:
   a. General: Each item or assembly of items shall be furnished completely wired to individual terminal blocks for connection to single branch electrical circuit. All electrical accessories and controls required by equipment shall be furnished. Provide terminal blocks for controls and interlocks not included in equipment package. Manual and magnetic starters shall have ambient compensating running overcurrent protection in all ungrounded conductors. Magnetic starters shall be manual reset, shall have H-O-A switches and auxiliary contacts. Controllers and other devices shall be in NEMA 1 or 3R enclosures as applicable.
   b. Wiring: Conductors, conduit, and wiring shall be in accordance with Electrical Specifications. Individual items within assembly shall be separately protected with dead front, fused disconnect, fuse block, or circuit breaker for each ungrounded conductor, all accessible on operating side of equipment. Switches, contacts, and other devices shall be in ungrounded conductors.
   c. Motors: Shall be rated, constructed, and applied in accordance with NEMA and ANSI Standards without using service factor. Single-phase motor shall be of type to suit application. Three-phase motors shall be open drip proof, NEMA B design

on pumps and fans, NEMA C on reciprocating equipment, sealed ball bearing, three-phase induction unless otherwise noted. Design shall limit starting inrush current and running current to values shown on drawings. Motors 1 horsepower and larger shall be the premium efficiency type, tested according to IEEE Standard 112, Method B. Motors exposed to weather shall be TEFC. Motors in a fan air stream shall be TEFC or TEAO. Vertical motors outdoors shall be ODP or TEFC and shall have rain caps.

d. Starters: Motor starters shall be furnished for all equipment except where starter is in a motor control center as designated on the electrical drawings. Deliver starter to Electrical Contractor for installation and wiring.
e. Control Voltage: Equipment connected to greater than 240 volts shall be provided with 120 volt control circuit from integral protected transformer if separate source is not indicated on plans. 240 volt control is acceptable if confined within control panel.
f. Submittals: Included in shop drawings shall be internal wiring diagrams and manufacturer's recommend external wiring.

6. Fan Selection:
   a. Fan Curves: Performance curves shall be submitted for all units of 3000 CFM or greater. Operating point for forward curved fans shall be from point of maximum efficiency towards increased CFM limited by horsepower scheduled. Operating point for backward inclined fans shall be selected near point of maximum efficiency. Curves shall plot CFM verses static pressure with constant brake horsepower, RPM, and efficiency lines.
   b. Static Pressure: Unless otherwise noted, pressure scheduled as external static pressure (ESP) includes all ductwork and accessory losses external to the unit housing. Unless otherwise noted, pressure scheduled as total static pressure includes all ductwork, filter, coil, cabinet, damper, and other accessory losses. Unless otherwise noted, pressure scheduled as duct static pressure includes all supply and return ductwork and accessory losses external to the unit housing and plenum (as applicable). The allowance for filter losses is 0.3" WC, unless otherwise noted. Submit itemized static pressure losses for all components.
7. Filters:
   a. General: Tested and rated in accordance with ASHRAE Standard 52.2 and Title 24, C.C.R. Furnish and install one complete change of all filters after air balance in completed and prior to acceptance. Provide pressure differential gage across all filter banks.
   b. Filter Media: 2" media. MERV 13. Clean filter resistance 0.25" water at 500 fpm. Throw-away frame. Class 2. Camfil Farr AP.
   c. Pressure Differential Gage: Diaphragm actuated. 4" dial. Zero adjustment. Accuracy +/ - 2% of full scale. Range as required. Provide static pressure sensors, tubing, and mounting brackets. Dwyer Series 2000. Mark gage to indicate filter replacement pressure, coordinate point with filter and equipment manufacturers.
8. Mixing Dampers: Opposed blade, 16-gage. Six-inch maximum blade width, 48" maximum length. Nylon or oil impregnated bronze bearings. One-half inch diameter pin shaft. 16- gage channel frame. One percent maximum leakage at 4" WC in accordance with AMCA 500 for outside air dampers. Actuating rod out of air stream. Arrow.
9. Sound Ratings: Shall be in accordance with ASHRAE 36-72. Sound ratings shall not exceed scheduled values.
10. Drives: Unless noted as direct connected, drives shall be V-belt, rated at 150% of motor horsepower. Multiple drive belts shall be matched set. Drive sheaves shall be dynamically balanced, adjustable, range +/ - 10%, selected at mid-range. Adjustable relative movement shall be lockable to shaft. Belts shall be aligned within 1-1/2 degrees at all times. Open drives shall be provided with OSHA approved open mesh belt guards. Belt guards exposed to weather shall be weatherproof enclosure with louvered face for adequate ventilation. Driving motor shall be mounted on adjustable

rails. T.B. Woods, Browning. Submit RPM range of driven machine with drive selection.

B. Variable Refrigerant Flow (VRF) Air Conditioning Specification – Heat Pump:

1. All equipment under this section shall be Owner Furnished Contractor Installed (OFCI).

2. System Description:

a. The variable capacity, heat pump air conditioning system shall be a Samsung, Toshiba, Daikin, Mitsubishi, Carrier, Trane or approved equal. Variable Refrigerant Flow Series (heat/cool model) split system. The system shall consist of multiple evaporators using PID control, and condensing unit. The outdoor units shall be a nominal 3 ton, 4 ton, or 5 ton direct expansion (DX), air-cooled heat pump air-conditioning system, inverter driven variable speed compressor, multi-zone split system, using R-454B refrigerant. The outdoor unit may connect an indoor evaporator capacity up to 130% to that of the outdoor condensing unit capacity. All indoor units are each capable of operating separately with individual temperature control.

b. The outdoor unit shall be interconnected to indoor unit and shall range in capacity from 7,500 Btu/h to 54,000 Btu/h in accordance with manufacturer's engineering data book detailing each available indoor unit. The indoor units shall be connected to the condensing unit utilizing manufacturer's specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable.

c. Operation of the system shall permit either cooling or heating of all of the indoor units. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller, an Intelligent Touch Controller (ITC), an Intelligent Touch Manager (ITM) or a BMS interface.

3. VRF Features and Benefits:

a. Voltage Platform: Heat pump condensing units shall be available in 208-230V/1/60 configurations.

b. Advanced Zoning: A single system shall provide for up to 10 zones.

c. Independent Control: Each indoor unit shall use a dedicated electronic expansion valve for independent control.

d. VFD Inverter Control: Each condensing unit shall use a high efficiency, variable speed "inverter" compressor coupled with inverter fan motors for superior part load performance.

e. Compressor capacity shall be modulated automatically to maintain a constant suction pressure, while varying the refrigerant volume for the needs of the cooling or heating loads.

f. Indoor units shall use PID control to control superheat to deliver a comfortable room temperature condition.

g. Variable Refrigerant Temperature (VRT) Control: Each condensing unit shall utilize an algorithm to automatically adjust the refrigerant suction and condensing temperatures in response to the heating and cooling loads, and in response to the current weather conditions. The VRT control shall be capable of being customized in the following modes and sub-modes:

i. Automatic (factory preset): The Automatic VRT mode shall allow the target evaporator temperature (Te) and target condensing temperature (Tc) to float based on outdoor ambient temperature conditions, and shall incorporate the following sub-modes: Powerful, Quick, and Mild (factory preset).

ii. High Sensible: The High Sensible mode shall allow the system Te and Tc values to be programmed to series of fixed Te and Tc values. The High Sensible mode shall also be capable of incorporating the following sub-mode: Eco.

iii. Basic: The Basic mode shall disable the VRT control of the outdoor unit and allow the system to operate with constant Te and Tc values.

h. Flexible Design:

i. Linear piping distance between the condensing unit and furthest located indoor unit shall be per manufacturer's recommendations.
ii. Total "one-way" piping distance in the piping network shall be per manufacture's recommendations.
iii. Vertical (height) separation between the condensing unit and the indoor unit units shall be per manufacturer's recommendations.
iv. The outdoor unit shall connect an indoor evaporator capacity up to 130% of the outdoor condensing unit capacity.

i. Simple Wiring: Systems shall use 2 wire, multi-stranded, non-shielded and non polarized daisy chain control wiring.
j. Advanced Diagnostics: Systems shall include a self diagnostic, auto-check function to detect a malfunction and display the type and location.
k. Advanced Controls: Each system shall have at least one remote controller capable of controlling up to 16 indoor unit units.

4. Quality Assurance:
a. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.
b. All wiring shall be in accordance with the National Electric Code (NEC).
c. Each combination shall be rated in accordance with Air Conditioning, Heating and Refrigeration Institute's (AHRI) Standard 210/240 and bear the AHRI label.
d. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.
e. The outdoor unit will be factory charged with R-454B.

5. Delivery, Storage and Handling:
a. Unit shall be stored and handled according to the manufacturer's recommendations.

6. Standard Limited Warranty:
a. Manufacturer shall warrants original owner of the non-residential building, multifamily residence or residence in which the Carrier/Toshiba products are installed that under normal use and maintenance for comfort cooling and conditioning applications such products (the "Products") will be free from defects in material and workmanship. This warranty applies to compressor and all parts and is limited in duration to ten (10) years starting from the ''installation date'' which is one of the two dates below:
i. The installation date is the date that the unit is originally commissioned, but no later than 18 months after the manufacture date noted on the unit's rating plate.
ii. If the date the unit is originally commissioned cannot be verified, the installation date is three months after the manufacture date.

7. Outdoor Unit:
a. General: The outdoor unit is designed specifically for use with VRF series components.
i. 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 Carrier/Toshiba swing compressor, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separator, service ports and suction line accumulator. Liquid and suction lines must be individually insulated between the outdoor and indoor units.
ii. The outdoor unit can be wired and piped with outdoor unit access from the left, right, rear or bottom.
iii. The connection ratio of indoor units to outdoor unit shall be permitted up to 130%.
iv. The outdoor system shall be able to support the connection of up to 10 indoor unit's dependent on the model of the outdoor unit.
v. The sound pressure level standard shall be that value as listed in the engineering manual for the specified models at 3 feet from the front of the unit. The outdoor unit

shall be capable of operating automatically at further reduced noise during night time.

vi. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.

vii. The outdoor unit shall allow for side-by-side installation with minimum spacing.

viii. The following safety devices shall be included on the condensing unit; high pressure switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti recycling timers.

ix. To ensure the liquid refrigerant does not flash when supplying to the various indoor unit units, the circuit shall be provided with a sub-cooling feature.

x. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation.

xi. The outdoor unit shall be capable of heating operation at 0°F dry bulb ambient temperature without additional low ambient controls.

b. Unit Cabinet:

i. The outdoor 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.

c. Fan:

i. The condensing unit fan(s) shall consist of propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.

ii. The fan shall be a horizontal discharge configuration with a nominal airflow maximum range of 3,740 CFM.

iii. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.

iv. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

d. Condenser Coil:

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

ii. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.

iii. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube.

iv. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.

v. E-coated Aluminum-Fin Evaporator and Condenser Coils (3-Phase Models Only):

1) Shall have a flexible epoxy polymer coating uniformly applied to all coil surface areas without material bridging between fins.

2) Coating process shall ensure complete coil encapsulation of tubes, fins and headers.

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3) Color shall be high gloss black with gloss per ASTM D523.

4) Uniform dry film thickness from 0.8 to 1.2 mil on all surface areas including fin edges.

5) Superior hardness characteristics of 2H per ASTM D3363 and cross-hatch adhesion of R-454B per ASTM D3359.

6) Impact resistance shall be up to 160 in.-lb (ASTM D2794).

7) Humidity and water immersion resistance shall be up to minimum 1000 and 250 hours respectively (ASTM D2247 and ASTM D870).

8) Corrosion durability shall be confirmed through testing to be no less than 1000 hours salt spray per ASTM B117.

e. Compressor:

i. The compressor shall be variable speed controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity shall be controlled to eliminate deviation from target value.
ii. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed swing type.
iii. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
iv. The capacity control range shall be 14% to 100%.
v. The compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
vi. Oil separators shall be standard with the equipment together with an intelligent oil management system.
vii. The compressor shall be spring mounted to avoid the transmission of vibration.

f. Electrical:
i. The power supply to the outdoor unit shall be 208/230 volts, 1 phase, 60 hertz +/- 10%.
ii. The control voltage between the indoor and outdoor unit shall be 18VDC non-shielded, stranded 2 conductor cable.
iii. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.

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8. Concealed Ceiling Ducted Unit:

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a. General: The indoor unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-454B, equipped with an electronic expansion valve, for installation into the ceiling cavity. It is constructed of a galvanized steel casing. It shall be available in capacities from 72,000 Btu/h to 96,000 Btu/h. Indoor unit to be connected to outdoor unit heat pump. It shall be a horizontal discharge air with horizontal return air configuration. All models feature a low height cabinet making them applicable to ceiling pockets that tend to be shallow. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature when used with remote control. The indoor units sound pressure shall be 48 dB(A) at low speed measured 5 feet below the ducted unit.
b. Performance: Each unit's performance is based on nominal operating conditions.
c. Indoor Unit:
i. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an adjustable external static pressure switch.
ii. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
iii. Both refrigerant lines shall be insulated from the outdoor unit.
iv. The indoor units shall be equipped with a return air thermistor.
v. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
vi. The voltage range will be 253 volts maximum and 187 volts minimum.
d. Unit Cabinet:
i. The cabinet shall be located into the ceiling and ducted to the supply and return openings.

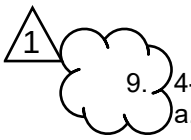
ii. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

e. Fan:
   i. The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high and low fan speeds available.
   ii. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz, with a motor output of 0.51 HP.
   iii. The airflow rate shall be available in high and low settings.
   iv. The fan motor shall be thermally protected.
   v. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.

f. Coil:
   i. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
   ii. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
   iii. The coil shall be a 3 row cross fin copper evaporator coil with 13 fpi design completely factory tested.
   iv. The refrigerant connections shall be flare connections and the condensate will be 1-5/16 inch outside diameter PVC.
   v. A thermistor will be located on the liquid and gas line.

g. Electrical:
   i. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
   ii. Transmission (control) wiring between the indoor and outdoor unit shall be per manufacturer's recommendations.
   iii. Transmission (control) wiring between the indoor unit and remote controller shall be per manufacturer's recommendations.

h. Control:
   i. The unit shall have controls provided to perform input functions necessary to operate the system.
   ii. The unit shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.
   iii. The unit shall be compatible with a Daikin Intelligent Touch Manager advanced multi-zone controller.



9. 4-Way Ceiling Cassette Indoor Unit:

a. The indoor unit shall be a ceiling cassette fan coil unit for installation into the ceiling cavity equipped with an air panel grille to be connected to indoor unit as scheduled and specified in this section. The indoor unit shall have a four-way air distribution type, ivory white, impact resistant, and washable decoration panel. The supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0 degree to 90 degree angle.

b. Acoustic Performance: The indoor units sound pressure shall range from 27 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.

c. Construction:
   i. The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3 minute fused time delay, and test run switch.
   ii. The 4-way supply airflow shall be field modifiable to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
   iii. Return air shall be through the concentric panel, which shall include a filter.
   iv. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 25" of lift.

v. The indoor units shall be equipped with a return air thermistor.
vi. The indoor unit shall be separately powered with 208-230V/ 1-phase/60Hz.
vii. The voltage range shall be 253 volts maximum and 187 volts minimum.

d. Unit Cabinet:
i. The cabinet shall be space saving and shall be located into the ceiling.
ii. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
iii. Provide fresh air intake kit where used and indicated on the drawings. A branch duct knockout shall exist for branch ducting supply air.
iv. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

e. Fan:
i. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.
ii. The indoor unit shall operate with a power supply of 208/230 volts, 1 phase, 60 hertz. The allowable voltage range shall be 187 to 253 volts.
iii. The airflow rate shall be adjustable and have high, medium and low fan settings.
iv. The fan motor shall be thermally protected.

f. Filter: The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

g. Coil:
i. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
ii. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
iii. The refrigerant connections shall be flare connections and the condensate shall be 1-1/4 inch outside diameter PVC.
iv. A condensate pan shall be located under the coil.
v. A condensate pump with a 25 inch lift shall be located below the coil in the condensate pan with a built in high level safety alarm to shut down the unit.
vi. A thermistor shall be located on the liquid and gas line.

C. Exhaust Fans:
1. General: All exhaust fans shall be tested and rated in accordance with AMCA Standard 210. Fans exposed to the weather shall have ventilated weatherproof housing over motor and drive assembly.
2. Ceiling Fan: Ceiling mounted direct drive centrifugal exhaust fan with exhaust grille. Motor mounted on rubber-in-shear isolators. Motor and fan removable through grille. Acoustically lined housing. Backdraft damper. UL listed. Penn, Cook, ACME, Greenheck or equal.
3. In-Line Fan: Attic mounted direct drive centrifugal exhaust fan. Motor shall be open drip proof with permanently lubricated sealed bearings and built-in thermal overload protection and disconnect plug. Acoustic lined housing. Backdraft damper. UL listed. Provide 24”x24” access panel with cylinder key lock when above hard ceiling. Penn, Cook, ACME, Greenheck or equal.

PART 3 EXECUTION

3.1 DUCTWORK INSTALLATION

A. General:
1. Standards: Unless otherwise noted, all ductwork shall be constructed and installed in accordance with current SMACNA "HVAC Duct Construction Standards". Ductwork and accessories shall be installed in a manner to prevent vibration and rattling.
2. Seismic Bracing: All ducts shall be braced and supported per details on the drawings.

3. Duct Access Doors: Provide access doors as required to adjust equipment and dampers.
4. Flexible Connections: Connections of ductwork to all equipment shall be with 6" (min.) flexible connection. Install with ample slack and uniform gap after deflection of vibration isolators. There shall be no metal to metal contact across flexible connection. Protect outdoor connections with weatherproof metal shroud on top and sides, no metal-to-metal contact. Provide at all seismic joints.
5. Ducted Returns: All air handling that is not directly located in the space that it serves shall have ducted returns.
6. Open ends of ductwork shall be covered during construction to keep inside clean.

B. Low Velocity-Low Pressure (up to 2000 ft/ min; up to 2.0 in. water):
1. Sheet Metal Ductwork:
   a. Ells: Ells with less than standard radius and square ells shall be fitted with turning vanes.
   b. Tees: Tees shall be straight tap-in with extractor or 45 degree takeoff, as shown on drawings.
   c. Duct Joints: Seal duct joints airtight with fiber tape and adhesive per manufacturer's printed instruction. Ducts in weather shall be sealed air and watertight with duct mastic before closing and taping.
      1) Where Ductmate type joints are used, the manufacturer's designated procedure shall be followed. Ductmate joints on roof shall have continuous cleat on top duct flange to prevent water from collecting on gasket.
   d. Dampers: Install volume control damper and damper regulator in all branch ducts.
   e. Duct dimensions shown on drawings for lined ducts, are clear net openings inside of lining.
   f. Top of ducts exposed to weather shall be cross broken and sloped slightly to each side to allow rainwater to run off. Ducts that do not drain off top will be rejected and need to be replaced at contractors' expense.
2. Flexible Glass Fiber Ductwork: Hangers shall be 2" wide metal straps spaced to prevent sagging, 3 feet spacing maximum. Insert 6" wide fiberglass pad between duct and hanging strap. All joints and fittings shall be sheet metal and shall be installed with metal bands or 3 (min) self-tapping screws and fiber tape. Maximum length of flexible duct shall be 5 ft. Single piece minimum length shall be 3 ft. Minimum turn radius shall be in accordance with SMACNA Standards (turn radius to duct centerline not less than 1.5 times the duct diameter).

3.2 AIR TERMINALS AND DUCT FITTINGS INSTALLATION

A. General: Unless otherwise noted, all air terminals and duct fittings shall be installed in accordance with current SMACNA "HVAC Duct Construction Standards", details on drawings and manufacturer's instructions. Terminals and fittings shall be installed in a manner to prevent vibration and rattling.

B. Fire Smoke Damper: Fire smoke dampers shall be installed in accordance with their State Fire Marshal approval and the manufacturer's recommendations.

C. Gym: Attach safety cable to inside of duct and to grille neck with #10 sheet metal screws.

3.3 DUCTWORK INSULATION INSTALLATION

A. General: All supply and return sheet metal ductwork shall be insulated.

B. Concealed Ductwork: Wrap ductwork with fiberglass blanket lapped 2" minimum. Secure with foil tape at all joints for a complete vapor barrier.

C. Acoustic Lining: All ductwork in equipment rooms, where exposed to weather, and elsewhere as indicated on drawings, shall have acoustic lining. Increase each sheet metal dimension to accommodate lining and maintain clear inside duct dimensions shown on drawings. Apply lining with bonding adhesive in accordance with manufacturer's recommendations and secure with mechanical fasteners in accordance with SMACNA Standards. Seal exposed edges of lining with bonding adhesive.

3.4 PIPING INSTALLATION

A. General:
1. Piping Layout: Piping shall be concealed in walls, above the ceilings, or below grade unless otherwise noted. Exposed piping shall run parallel to room surfaces; location to be approved by Architect. No structural member shall be weakened by cutting, notching, boring or otherwise unless specifically allowed by structural drawings and/ or specifications. Where such cutting is required, reinforcement shall be provided as specified or detailed. All piping shall be installed in a manner to ensure unrestricted flow, eliminate air pockets, prevent any unusual noise, and permit complete drainage of the system. All piping shall be installed to permit expansion and contraction without strain on piping or equipment. Expansion joints and/or flexible connectors shall be installed as required. Vertical lines shall be installed to allow for building settlement without damage to piping. Lines shall be adequately braced against vertical and lateral movement.
2. Pipe Support:
   a. General: Hangers shall be placed to support piping without strain on joints or fittings. Maximum spacing between supports shall be as specified below. Actual spacing requirements will depend on structural system. Refer to drawings for additional requirements and attachment to structure. Vertical piping shall be supported at floor and ceiling. Support pipe within 12" of all changes in direction. No perforated straphanger shall be used in any work.
   b. Refrigerant Piping: Pipe shall be cut square. Joint surfaces shall be thoroughly cleaned, fitted, and erected before brazing. Install specified accessories. After installation, evacuate to 29 inches of mercury, ambient temperature during evacuation shall not be less than 70 degrees F. After evacuation, fill with dry nitrogen to 250 psi and maintain for two-hour period without additional charge. After nitrogen test, purge with refrigerant charged through dryer and maintain holding charge in system and equipment. Refrigerant piping below grade shall be run in 4” (min.) PVC conduit with long radius ells. Seal ends of conduit watertight.
   c. Flue Piping: Flue piping shall be installed in accordance with its UL listing and manufacturer's instructions. All welders shall be certified in accordance with AWS Standard D9.1, Specifications for welding sheet metal.
   d. PVC Piping: Shall be cut square and assembled prior to solvent weld. Apply primer per manufacturer’s recommendations. Coat male joint fully with solvent, make joint before solvent dries and wipe exterior clean.

3.5 PIPING INSULATION INSTALLATION

A. Refrigerant Piping: Cover suction piping with foamed plastic insulation. Longitudinal and end seams shall be thoroughly cemented with adhesive in accordance with manufacturer's recommendation. Cover all fittings, unions, valves, and connections. Piping exposed to weather shall be covered with aluminum jacketing, seal all joints and seams with grey outdoor mastic or silver silicone sealant. Piping exposed in room shall be covered with piping chase painted to match wall.

3.6 EQUIPMENT INSTALLATION

A. General: It shall be the responsibility of the contractor to ensure that no work done under other specification sections shall in any way block, or otherwise hinder access panels or diminish the effectiveness of equipment vibration isolation.

B. Connections to Equipment: Where size reductions are required for connections to equipment, they shall be made immediately adjacent to the equipment and, if possible, inside the equipment cabinet. Connections made to equipment mounted on vibration isolators shall be with flexible connectors, installed adjacent to equipment.

C. Start Up: Engage manufacturer or factory-authorized service representative to perform start up supervision. Manufacturer shall provide on-site start up and commissioning assistance through job completion. Complete installation and start up checks according to manufacturer's written instructions.

3.7 TEMPERATURE CONTROL SYSTEM

A. Thermostats shall have the capability of terminating all heating at a temperature of no more than 70 degrees F or terminating all cooling at a temperature of no less than 78 degrees F, and to provide a temperature range of up to 10 degrees F between full heating and full cooling. Thermostats shall be 7 day programmable, Carrier, Robertshaw or equal with sub-base capable of battery backup or capacitor to retain program in the event of a power outage. All control wiring, regardless of voltage, shall be installed in conduit.

3.8 SYSTEM AIR BALANCE

B. Scope: Provide services necessary to initially deliver the air quantities shown on the plans and finally to balance for uniform temperature in the spaces served. Adjust all elements in grilles and diffusers for proper air distribution and to minimize drafts. Submit final Air Balance Report for approval before final completion of the construction contract. Comply with SMACNA manual for the balancing and adjustment of air distribution systems.

C. As a minimum, the balance report shall include CFM and neck size at each supply, return and exhaust grille, total CFM and external static pressure for all air moving equipment, and name plate and actual motor amps for indoor air fans.

D. Scope: Provide the services of a qualified independent test and balance agency certified by the Associated Air Balance Council (AABC) or The National Environmental Balancing Bureau (NEBB) to test, adjust and balance, retest, and record performance of the system to obtain design quantities as specified. Balancing contractor must also be TABB certified.

E. Qualifications: Prior to commencing work, the agency shall be approved by the Owner's Representative.

F. Instruments: All instruments shall be accurately calibrated; calibration histories shall be available for examination. Application of instrumentation shall be in accordance with AABC standards.

G. Procedure: General: Balanced quantities shall be plus 10%, minus 10% of design quantities. All name-plate data, manufacturer, model, and serial numbers shall be recorded for each item tested. All outside air flow listed in minimum.

H. Extended Warranty: The test and balance agency shall include an extended warranty of 90 days after completion of test and balance work, during which time the Owner's Representative at his discretion may request a recheck or resetting of any item or items in test report. The agency shall provide technicians to assist the Owner's Representative in

making any tests he may require during this period of time.

I. Air Balance Procedure (for each Air Handling System):
1. All air filters shall be clean when air balance is performed.
2. Provide a sketch of the equipment showing exactly where all pressure readings were taken.
3. Adjust blower RPM to design requirements.
4. Record motor full load amperes.
5. Make pitot tube traverse of main supply and return ducts and obtain design CFM at fans.
6. Record system static pressures, inlet, and discharge.
7. Record filter quantity, size(s) and pressure drop across filter(s) at each filter bank.
8. Adjust system for design CFM recirculated air.
9. Adjust system for design CFM outside air minimum settings.
10. Record entering air temperatures. (DB heating, DB and WB cooling.)
11. Record leaving air temperatures. (DB heating, DB and WB cooling.)
12. Adjust all main supply and return air ducts to design CFM.
13. Adjust all zones to design CFM, supply, and return.
14. Adjust all diffusers, grilles, and registers to plus 10%, minus 0% of design requirements.
15. Adjust CFM at all exhaust fans, make-up units, etc. (high and low speed, where applicable). Record applicable data from items 1 through 11 above.
16. Each grille, diffuser and register shall be identified as to location.
17. Verify proper diffusion pattern for all ceiling grilles and that all sidewall grilles are set for 5 degrees downward deflection unless otherwise noted. Make a notation of any that are not set properly.
18. Size, type and manufacturer of diffusers, grilles, registers, and all tested items shall be identified and listed. Manufacturer's ratings shall be used to make required calculations on all items.
19. Readings and tests of diffusers, grilles, and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustments.
20. In cooperation with the control manufacturer's representative, set adjustments of automatically operated dampers to operate as specified. Testing agency shall check all controls for proper calibrations and list all controls requiring adjustment by control installers.
21. All diffusers, grilles and registers shall be adjusted for required air patterns and to minimize drafts.
22. As a part of the work of this contract, THE AIR CONDITIONING CONTRACTOR shall make any changes in pulleys, belts, dampers, or the addition of dampers cleaning of insect screens and replacement of filters required for correct balance as recommended by air balance agency, at no additional cost to Owner.
23. Set, test, and adjust packaged heating/ cooling unit economizer operation in cooperation with controls contractor. Record minimum and maximum outside and exhaust airflows.

J. Water Balance Procedure:
1. Set valves for maximum coil flow.
2. Remove and clean all strainers.
3. Examine water in system and determine if water has been treated and cleaned.
4. Check expansion tanks to determine that they are properly charged, and that the system is completely full of water. Bleed air from system.
5. Adjust water flow through boilers, to design flow.
6. Record leaving and return water temperatures at boiler. Reset to correct design temperature.

7. Record the following at each coil:
   a. Inlet water temperatures.
   b. Leaving water temperatures.
   c. Pressure drop across coil.
   d. Pressure drop across bypass valve.
8. Record pump suction and discharge pressures at operating condition and with pump discharge valve completely closed.
9. Record running amperage of pump motor at operation condition and with pump discharge valve completely closed.
10. Record water metering device readings.

K. Test, adjust, and retest water bleed rates from evaporative coolers. Record all data.

L. Acoustic Performance Testing: Provide acoustic performance testing in accordance with the requirements of EQ3.0 of the "California Criteria for High Performance Schools, Best Practices Manual, 2009 Edition".
   1. Maximum Background Noise Level: Unoccupied classrooms must have a maximum background noise level of no more than 45 dBA LAeq. The standard anticipates two primary noise sources, steady HVAC equipment noise and the usually unsteady exterior environmental noise. Where the measured ambient noises due to sources other than HVAC are within 5 dB of the measured overall noise (HVAC and exterior intrusive noise) a measurement of at least ½ hour duration shall be made in at least two classrooms in each building in the worst case (noisiest) locations on the school site during normal school days and hours.
      a. To evaluate the significance of intrusive exterior noise, a 30-minute Equivalent Sound Level (LAeq30, in general conformance with ANSI S12.60-2002, Annex E3) measurement shall be made in the classroom that is subjectively assessed to represent the worst case exposure to exterior noise, with the HVAC system not in operation. This Leq30 measurement shall be repeated with the HVAC in operation. If the second "HVAC-on" sound level is more than 5 dB greater than the initial "HVAC-off" measurement, exterior noise intrusion shall be deemed "not significant".
      b. Where intrusive exterior noise has been deemed "not significant" short-term (15 second) A-weighted sound level measurements shall be made in each classroom with the HVAC systems in operation. Where exterior intrusive noise has been deemed "significant" (per the evaluation method noted above), LAeq30 sound level measurements shall be made in each classroom with the HVAC system in operation. In either case, where classrooms are served by variable-air-volume systems, the systems shall be operated at maximum nominal flow (typically by means of varying the thermostat set point).
      c. Where exposure to exterior noise varies significantly between groups of classrooms (e.g. one side of a classroom wing adjacent to a street, the other side facing away), separate evaluations of exterior noise significance can be conducted to limit the need for LAeq30 measurements.
   2. Maximum Reverberation: Classrooms less than 10,000 cubic feet must have a 0.6-second maximum (unoccupied) reverberation time and classrooms with volumes between 10,000 cubic feet and 20,000 cubic feet must have a 0.7-second maximum (unoccupied, furnished, and fitted-out) reverberation time. (ANSI Standard S12.60-2002). The reverberation times shall be measured in each classroom in three octave bands with center frequencies of 500, 1000, and 2000 Hz. The arithmetic average of the three measured values shall be compared to the standard.

END OF SECTION 23 00 01

SECTION 23 09 23 - DIRECT DIGITAL CONTROLS

PART 1 – GENERAL

1

1.0 OWNER FURNISHED CONTRACTOR INSTALLED (OFCI) EQUIPMENT

A. The thermostat shall be provided with the VRF system (OFCI).
B. CoolMaster interface shall be provided with the VRF system (OFCI).
C. Airthings CO2 monitor shall be provided with the VRF system (OFCI).

1.1 RELATED DOCUMENTS

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

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Heating and cooling piping:

1. Control valves
2. Flow meters
3. Flow switches
4. Press and temp sensor wells & sockets
5. Temp sensor wells and sockets

B. Duct accessories:

1. Airflow stations
2. BAS control dampers
3. Terminal unit controls

1.3 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITH THE WORK OF THIS SECTION

A. Communications with Third Party Equipment:

1. Any additional integral control systems included with the products integrated with the work of this section shall be furnished with a BACnet interface for integration into the Direct Digital Control System described in this section (reference sequence of operations and points list for specifics). Those systems include:

a. Boilers

b. Chillers

c. Cooling Towers

d. Switchgear

e. Variable Speed Drives

f. Computer Room Units (MDF)

g. Rooftop Units

1.4 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:

1. Division 01- General

2. Division 23 – Mechanical

3. Division 26 – Electrical

1.5 DESCRIPTION

A. General: The control system shall consist of a complete BAS system with a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphics. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface. If individual software seat licenses or keys are required provide a minimum of 4 additional licenses to accommodate multiple owner operators.

B. If manufacture offers a web-based BAS platform, the installing contractor shall provide the new web-based software and software updates required for this project. Additionally the installing contractor shall provide all computer related components (BAS web server – reference specifications for hardware requirements) for the new software platform to function in a peer-to-peer environment.

C. The system shall directly control HVAC equipment as specified in Sequences of Operation. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints.

D. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. Schedules, setpoints, trends, and alarms specified shall be BACnet objects.

1.6 APPROVED CONTROL SYSTEMS

A. The following are approved control system suppliers, manufacturers, and product lines:

1. WebCTRL® – Installed by AutomatedLogic, Houston Office

2. Reliable Controls – Installed by Unify Energy Solutions

1.7 QUALITY ASSURANCE

A. Installer and Manufacturer Qualifications

1. Installer shall have an established working relationship with Control System Manufacturer for a period of 10 years or greater. If the distributorship has not had duration of more than 10 years, the contractor will not be approved without the written approval prior to bid date (no exceptions).
2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

3. BAS Graphics shall be Three Dimensional Thermographic.

4. BAS provider shall warranty controllers for 10 years.

5. BAS Provider shall provide lifetime training for the lifecycle of the facility to the owner at no additional cost.

1.8 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authority's codes and ordinances for these plans and specifications. At a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

1. National Electric Code (NEC)

2. International Energy Conservation Code (IECC)

3. International Building Code (IBC)

4. Uniform Mechanical Code (UMC)

5. ASHRAE Standard 135-2016: BACnet - A Data Communication Protocol for Building Automation and Control Networks

1.9 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 seconds.

2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 seconds and shall automatically refresh every 15 seconds.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 seconds.

4. Object Command. Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.

5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 seconds.

6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with the mechanical process under control.

7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.

8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 seconds of other workstations.

9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.

Control Stability and Accuracy. Control loops shall maintain measured variable at set point within tolerances listed in Table 2.

Table1
Reporting Accuracy

Measured Variable	**Reported Accuracy**
Space Temperature	±2ºF
Ducted Air	±2ºF
Outside Air	±2ºF
Dew Point	±3ºF
Water Temperature	±2ºF
Delta-T	±0.25ºF
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±0.1 in. w.g.
Air Pressure (space)	±0.01 in. w.g.
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm

Note 1: 10% - 100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±0.2 in. w.g. ±0.01 in. w.g.	0-6 in. w.g. -0.1 to 0.1 in. w.g.
Airflow	±10% of full scale	
Space Temperature	±2.0ºF	
Duct Temperature	±3ºF	
Humidity	±5% RH	
Fluid Pressure	±1.5 psi ±1.0 in. w.g.	1-150 psi 0-50 in. w.g. differential

1.10 SUBMITTALS

A. Product Requirements: Provide one electronic copy and 4 hard copies of shop drawings and other submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been approved for conformity with design intent. If requested, provide drawings as AutoCAD 2017 and 4 prints of each drawing on 8.5 x 11 paper and 1 electronic copy of each drawing. When manufacturer's cut sheets apply to a product series rather than a specific product, **clearly indicate applicable data by highlighting** or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Provide submittals on the following:

1. Direct Digital Control System Hardware

a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

1. Direct digital controllers (controller panels)

2. Transducers and transmitters

3. Sensors (include accuracy data)

4. Actuators

5. Valves

6. Dampers

7. Relays and switches

8. Control panels

9. Power supplies

10. Batteries

11. Operator interface equipment

12. Wiring

c. Wiring diagrams and layouts for each control panel. Show termination numbers.

d. Floor plan schematic diagrams indicating field sensor and controller locations.

e. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software

a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.

b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

1. Central Processing Unit (CPU) or web server

2. Monitors

3. Keyboards

4. Power supplies

5. Battery backups

6. Interface equipment between CPU or server and control panels

7. Operating System software

8. Operator interface software

9. Color graphic software

10. Third-party software

c. Schematic diagrams of control, communication, and power wiring for central system installation. Show interface wiring to control system.

d. Network riser diagrams of wiring between central control unit and control panels.

3. Controlled Systems

a. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.

b. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.

c. Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

d. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system. List I/O points and software points specified. Indicate alarmed and trended points.

4. Description of process, report formats, and checklists to be used in Section 23 09 23 Article 3.15 (Control System Demonstration and Acceptance).

B. Schedules

1. Within two months of contract award, provide schedule of work indicating:

a. Intended sequence of work items

b. Start date of each work item

c. Duration of each work item

d. Planned delivery dates for ordered material and equipment and expected lead times

e. Milestones indicating possible restraints on work by other trades or situations

2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

C. Project Record Documents. Submit 8 copies of record (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:

1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2017 and 6 prints of each drawing on 8 ½” x 11" paper.

2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of (Control System Demonstration and Acceptance).

3. Operation and Maintenance (O&M) Manual. Printed, electronic, or online help documentation of the following:

a. As-built versions of submittal product data.

b. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.

c. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.

d. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

f. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.

g. Graphic files, programs, and database on magnetic or optical media.

h. List of recommended spare parts with part numbers and suppliers.

i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

j. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.

k. Licenses, guarantees, and warranty documents for equipment and systems.

l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

D. Training Materials: The contractor shall provide training to owner personnel in a laboratory classroom environment. Each student shall be provided with a dedicated computer workstation utilizing a simulated BAS software platform that is installed for this project. The instructor's shall have CEU accreditation for all training courses offered. Provide documentation for this requirement in the initial BAS submittal. If contractor does not have CEU instructor or offer these courses locally include cost for tuition, travel and boarding to send students to manufacturer training facility. The owner shall receive free training for the life of the system.

1. Operator Overview – Consists of general system navigation, scheduling functions, setpoint modifications and parameter adjustments.

2. Advanced Topics Overview – Detailed analysis of trend setup/configuration, trend historian, alarm setup, alarm actions (email, printing, etc.), point renaming, and detailed analysis of equipment parameters.

3. Program/Logic Manipulation – Modify system programs as needed for additions and modifications.

4. Graphic Manipulation – Modify system graphics as needed for additions and modifications.

5. Hardware Troubleshooting – Classroom setup shall have HVAC mock-up systems. Operators shall be able to interact with this live system through the BAS utilized for this project. Class will provide students the ability to identify and repair common problems regularly encountered.

6. Software Troubleshooting - Classroom setup shall have HVAC mock-up systems. Operators shall be able to interact with this live system through the BAS utilized for this project. Class will provide students the ability to identify and repair common issues that can be utilized via software modifications.

7. Central Plant Operation – At a minimum the instructor shall thoroughly explain different types of central plant equipment and proper system modifications that can be made to enhance system performance and energy savings.

8. HVAC System Training – Objective of this class is to provide basic HVAC system knowledge of various types of systems including types of air side distribution and water side distribution. Topics such as thermodynamics, psychometrics, de-humidification, and demand control ventilation shall be thoroughly explained.

1.11 WARRANTY

A. Warrant work as follows:

1. Warrant materials for specified control system and peripheral control devices free from defects for a period of **3 years** after certificate of substantial completion. Warrant all labor for a period of **1 year** after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request. Additionally contractor shall offer 24/7 after-hours support to include alarm monitoring and associated dispatch service.

2. Provide graphic modifications for a period of 3 years from date of substantial completion. This shall include room number and equipment modifications as requested by the owner.

3. Provide telephone support free to the owner for a period of 3 years after substantial completion. This service includes technical support for all BAS equipment and shall include troubleshooting and problem resolution via the telephone or web services. Service shall be available during the hours of 7am to 5pm Monday – Friday.

4. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

5. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Contractor or Owner identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.

6. Exception: Contractor shall not be required to warranty existing devices except those that have been rebuilt or repaired during installation.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics

2. Record drawings

3. Database

4. Application programming code

5. Documentation

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ASHRAE/ANSI Standard 135-2016, BACnet.

B. Use existing Ethernet backbone for network segments marked "existing" on project drawings.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Sequence of Operations. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated

controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

G. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable the system to both read and write data.

1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.

2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.

3. For read or write requests, the system shall require user name and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.

2.3 OPERATOR INTERFACE

A. Operator Interface. Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information. Existing manufacturer's BAS web server and workstation can be utilized. In addition to the primary operator interface, the system shall include a secondary interface compatible with a locally available commercial wireless network and viewable on a commercially available wireless device such as a Wireless Access Protocol (WAP) enabled cellular telephone or personal digital assistant (PDA). This secondary interface may be text-based and shall provide a summary of the most important data. As a minimum, the following capabilities shall be provided through this interface:

1. An operator authentication system that requires an operator to log in before viewing or editing any data, and which can be configured to limit the privileges of an individual operator.

2. The ability to view and acknowledge any alarm in the system. Alarms or links to alarms shall be provided on a contiguous list so the operator can quickly view all alarms.

3. A summary page or pages for each piece of equipment in the system. This page shall include the current values of all critical I/O points and shall allow the operator to lock binary points on or off and to lock analog points to any value within their range.

4. Navigation links that allow the operator to quickly navigate from the home screen to any piece of equipment in the system, and then return to the home screen. These links may be arranged in a hierarchical fashion, such as navigating from the home screen to a particular building, then to a specific floor in the building, and then to a specific room or piece of equipment.

B. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135-2016, BACnet Annex J.

C. Hardware. If providing a new server, each workstation or web server shall consist of the following:

1. Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified in Section 23 09 23 Paragraph 1.8. Hard disk shall have sufficient memory to store system software, one year of data for trended points specified in Sequences of Operation, and a system database at least twice the size of the existing database at system acceptance. Configure computers and network connections if multiple computers are required to meet specified memory and performance. Web server shall be Compaq Rack Mounted Server (or equal) with a minimum of:

   a. Dual Processor Intel Pentium 3.66 GHz processor

   b. 1 GB RAM

   c. 80 GB hard disk providing data at 100 MB/sec

   d. RAID 5 Configuration

   e. 128x CD-ROM drive

   f. Most Current Windows Server Operating System

   g. Serial, parallel, and network communication ports and cables required for proper system operation.

2. If providing a server the server shall support one or more the following database types:

   a. SQL Server 2012 R2
   b. PostgreSQL
   c. MySQL
   d. MS Access

D. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:

1. Log In and Log Out. System shall require user name and password to log in to operator interface.

2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.

3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.

4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.

5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.

6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.

7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.

8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.

9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

E. System Software.

1. Operating System: Web server or workstation shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Windows XP Pro, Red Hat Linux, or Sun Solaris.

2. System Graphics: Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint. Graphics shall

   a. Functionality: Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

   b. Animation: Graphics shall be able to animate by displaying different image files for changed object status.

   c. Alarm Indication: Indicate areas or equipment in an alarm condition using color or other visual indicator.

   d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser

standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

F. System Tools. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

2. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.

3. System Configuration. Operators shall be able to configure the system.

4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.

5. Security. System shall require a user name and password to view, edit, add, or delete data.

   a. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object. Authorized operators shall be able to vary and deny each operator's accessible functions based on equipment or geographic location.

   b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.

   c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).

7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Section 23 09 93.Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

8. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.

9. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

10. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.

11. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. The contractor shall configure all physical control points and software control points to accumulate trend data. Analog values shall be configured utilizing time-based intervals and digital values shall be configured for COV. Provide at a minimum of 250 samples per control point. If data can be stored locally at the controller level this information shall be archived at the central server or all BAS workstations.

12. Object and Property Status and Control. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.

13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

14. Standard Reports. Furnish the following standard system reports:

    a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.

    b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.

    c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

        1. Alarm History.

        2. Trend Data. Operator shall be able to select trends to be logged.

        3. Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.

16. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.

17. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.

18. Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
    a. Language. Language shall be graphically based or English language oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. If English language oriented, language shall be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column-oriented or "fill-in-the-blanks."

    b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

    c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

    d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

    e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

    f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

    g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

        1. Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the

year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

2. System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

19. BACnet. Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2016, BACnet Annex L.

2.4 CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System Security. See Paragraph 2.3.F.5 (Security) and Paragraph 2.3.F.14.c.3 (Operator Activity).

C. Scheduling. See Paragraph 2.3.D.4 (View and Adjust Operating Schedules). System shall provide the following schedule options as a minimum:

1. Weekly. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).

2. Exception. Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.

3. Holiday. Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.

D. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

E. Binary and Analog Alarms. See Paragraph 2.3.F.7 (Alarm Processing).

F. Alarm Reporting. See Paragraph 2.3.F.9 (Alarm Reactions).

G. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

H. Maintenance Management. System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in Section 23 09 93.

I. Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in Section 23 09 93.

J. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

K. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

L. Energy Calculations.

1. System shall accumulate and convert instantaneous power (kW) or flow rates (gpm) to energy usage data.

2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

3. System shall calculate a fixed-window average. Window interval start shall be defined by utility meter digital input signal to synchronize system's and utility's fixed-window averages.

M. Anti-Short Cycling. Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

N. On and Off Control with Differential. System shall provide direct- and reverse-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.

O. Runtime Totalization. System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified.

2.5 CONTROLLERS

A. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Smart Actuators (SA) as required to achieve performance specified in Section 23 09 23 Article 1.8 (System Performance).

B. BACnet.

1. Building Controllers (BCs). Each BC shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ASHRAE/ANSI 135-2016, BACnet Annex L.

2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ASHRAE/ANSI 135-2016, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.

3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ASHRAE/ANSI 135-2016, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.

4. Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ASHRAE/ANSI 135-2016, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.

5. BACnet Communication.

   a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.

   b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

   c. Each AAC and ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

   d. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication.

1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.

4. Stand-Alone Operation. Each piece of equipment specified in Sequences of Operation shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

D. Environment. Controller hardware shall be suitable for anticipated ambient conditions.

1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20°F to 140°F.

2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.

E. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

F. Serviceability.

1. Controllers shall have diagnostic LEDs for power, communication, and processor.

2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.

3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

G. Memory.

1. Controller memory shall support operating system, database, and programming requirements.

2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

H. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft.).

I. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.6 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs. Binary outputs shall send a pulsed low-voltage signal for pulse width modulation control or an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall

have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. Pulse-Width Modulation. Control actuators designed for pulse-width modulation with a single binary output that cycle with variable on and off times as determined by the application software. Pulse-width modulation may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

J. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.7 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

    a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

    b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering.

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

    a. Dielectric strength of 1000 V minimum

    b. Response time of 10 nanoseconds or less

    c. Transverse mode noise attenuation of 65 dB or greater

    d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

2.8 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers.

1. Type. Control dampers shall have linear flow characteristics and shall be parallel- or opposed-blade type as specified below or as scheduled on drawings.

a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.

b. Other modulating dampers shall be opposed-blade.

c. Two-position shutoff dampers shall be parallel or opposed-blade with blade and side seals.

2. Frame. Damper frames shall 13 gauge galvanized steel channel or 1/8 in. extruded aluminum with reinforced corner bracing.

3. Blades. Damper blades shall not exceed 8 inches in width or 48 inches in length. Blades shall be suitable for medium velocity (2000 fpm) performance. Blades shall be not less than 16 gauge.

4. Shaft Bearings. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.

5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than (10 cfm per ft ^{2}) at (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of (1500 fpm).

6. Sections. Damper sections shall not exceed 48 in. - 60 in.. Each section shall have at least one damper actuator.

7. Linkages. Dampers shall have exposed linkages.

B. Electric Damper and Valve Actuators.

1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.

2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

3. Signal and Range. Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range.

4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.

5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 inch -.lb torque capacity shall have a manual crank.

6. Acceptable Manufacturers:

a. Belimo

C. Control Valves.

1. General. Select body and trim materials in accordance with manufacturer's recommendations for design conditions and service shown.

2. Type. Provide two or three-way control valves for two-position or modulating service as shown.

3. Water Valves.

   a. Valves providing two-position service shall be quick opening. Two-way valves shall have replaceable disc or ball.

   b. Close-off (Differential) Pressure Rating. Valve actuator and trim shall provide the following minimum close-off pressure ratings.

      1. Two-way: 100% of total system (pump) head.

      2. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

   c. Ports. Valves providing modulating service shall have equal percentage ports.

   d. Sizing.

      1. Two-position service: line size.

      2. Two-way modulating service: select pressure drop equal to the greatest of twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 35 kPa (5 psi).

      3. Three-way modulating service: select pressure drop equal to the smaller of twice the pressure drop through the coil exchanger (load) or 35 kPa (5 psi).

   e. Fail Position. Water valves shall fail normally open or closed as follows unless otherwise specified.

      1. Water zone valves: normally closed.

      2. Heating coils in air handlers: normally closed.

      3. Chilled water control valves: normally open.

      4. Other applications: as scheduled or as required by sequences of operation.

   f. Acceptable Valve and Actuator Manufacturers:

      1. Belimo

4. Steam Valves.

   a. Close-off (Differential) Pressure Rating. Valve actuator and trim shall provide minimum close-off pressure rating equal to 150% of operating (inlet) pressure.

   b. Ports. Valves providing modulating service shall have linear ports.
   c. Sizing.

1. Two-position service: select pressure drop equal to 10%-20% of inlet psig.

2. Modulating service at 100 kPa (15 psig) or less: select pressure drop equal to 80% of inlet psig.

3. Modulating service at 101-350 kPa (16-50 psig): select pressure drop equal to 50% of inlet psig.

4. Modulating service at over 350 kPa (50 psig): select pressure drop as scheduled on drawings.

D. Binary Temperature Devices.

1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 55°F-85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.

2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 55°F-85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.

3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 20 ft long. Element shall sense temperature in each 1 ft section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors.

1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 5 ft in length per 10 ft ^{2} of duct cross-section.

3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.

4. Space Sensors: Space sensors shall be stainless steel flush plate mounted type.

5. Differential Sensors. Provide matched sensors for differential temperature measurement.

F. Humidity Sensors.

1. Duct and room sensors shall have a sensing range of 20%-80%.

2. Duct sensors shall have a sampling chamber.

3. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°F-170°F.

4. Humidity sensors shall not drift more than 1% of full scale annually.

G. Flow Switches. Flow-proving switches shall be thermal dispersion type (IFM U 40100 or approved equal) or differential pressure type (air or water service). Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

1. Thermal dispersion type switches shall have relay output, wire break output and temperature output.

2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 4 enclosure unless otherwise specified.

H. Relays.

1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

I. Override Timers.

1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

J. Current Transmitters.

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

3. Unit shall be split-core type for clamp-on installation on existing wiring.

K. Current Transformers.

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

L. Voltage Transmitters.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.

2. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

M. Voltage Transformers.

1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.

2. Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.

3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

N. Power Monitors.

1. Power monitors shall be three-phase type and shall have three-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.

2. Power monitors shall provide selectable output: rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with 5 A current inputs and maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

O. Current Switches.

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

P. Pressure Transducers.

1. Transducers shall have linear output signal and field-adjustable zero and span.

2. Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.

3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.

4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi.) Transducer shall have 4-20 mA output, suitable mounting provisions, and 5-valve manifold.

Q. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

R. Pressure-Electric (PE) Switches. PE switches shall be UL listed, pilot duty rated (125 VA minimum) or motor control rated, metal or neoprene diaphragm actuated, operating pressure rated for 0-175 kPa (0-25 psig), with calibrated scale minimum setpoint range of 14-125 kPa (2-18 psig).

1. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application.

2. Switches shall be open type (panel-mounted). Exception: Switches shall be enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.

3. Each pneumatic signal line to PE switches shall have permanent indicating gauge.

S. Carbon Monoxide Detector / Controller / Transducer requirements:

1. Approved Manufactures:

   a. U.S. Draft Co.; Model CGM-505

2. Shall comply with Texas State Boiler code 65.603-2015.

3. ETL Listed to UL61010-1, CAN/CSA C22.2 No 61010-1, and LADBS Approved.

4. Boilers shall be individually hard wired.

5. Shall carry a (2) two year warranty.

6. Shall be calibrated every (18) eighteen months and a record of calibration shall be posted in a conspicuous place.

7. Shall be capable of displaying from 0-200 ppm of CO.

8. NEMA 1 enclosure.

9. Provide expansion board for additional equipment interlocks.

10. Provide pre-programmed dry contacts to shut down equipment during unsafe operation.

11. Fan relay actuation selectable with output for fan relay, alarm relay and 4-20ma signal.

12. Provide digital display, buzzer, fan delay.

13. Fan runtime shall have minimum.

14. Fan relays shall be pilot duty, SPDT, latching or non-latching at 5A, 240 VAC.

15. 0-10 VDC control signal out, visual alarm and audible alarm.

16. Alarm relay rating for 0.5A, 120V, 60VA.

17. Operating Environment from 0ºF to 125ºF at 10 to 90% RH.

T. Local Control Panels.

1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.

2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.

3. Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

2.9 WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.

B. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate Section 23 09 23 work with work of others. Controls Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.2 PROTECTION

A. Controls Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

B. Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site.

1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.

2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Submittals. See Section 23 09 23 Article 1.9 (Submittals).

C. Test and Balance.

1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.

2. Train Test and Balance Contractor to use control system interface tools.

3. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.

4. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.

D. Life Safety.

1. Duct smoke detectors required for air handler shutdown are provided and wired under Division 26.

2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23 and wired by Division 26.

3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 26.

E. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows.

1. Communication media and equipment shall be provided as specified in Section 23 09 23 Article 2.2 (Communication).

2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation described regardless of where within the contract documents those products are described.

3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.

4. Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3.4 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.5 FIELD QUALITY CONTROL

A. Commissioning and start-up of the BAS system shall be performed factory certified employees of the BAS contractor or manufacturer. Under no instances shall electrical subcontractors perform this work.

B. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in Section 23 09 23 Article 1.7 (Codes and Standards).

C. Continually monitor field installation for code compliance and workmanship quality.

D. Contractor shall arrange for work inspection by local or state authorities having jurisdiction over the work.

3.6 WIRING

A. To differentiate BAS wiring from that of other trades, all cable except for underground will have a **yellow outer jacket** (no exceptions).

B. Division 26 contractor shall supply a dedicated 120vac power to a junction box in each mechanical room for use by the BMCS.

C. A Conduit fill based on plenum 18 gauge 2 conductor:

1. 1/2 inch - No more than 4 conductors.

2. 3/4 inch - No more than 8 conductors.

3. 1 inch - No more than 12 conductors.

D. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations. Where the requirements of Section 23 09 23 differ from Division 26, Section 23 09 23 shall take precedence.

E. All wires whether control network or device wire shall be marked with Brady-type markers.

F. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC and Division 26.

G. Low-voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low-voltage power circuits as required to meet Class 2 current limit.

H. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

I. Install wiring in raceway where subject to mechanical damage and at levels below 10ft. in mechanical, electrical, or service rooms.

J. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

K. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

L. Do not install wiring in raceway containing tubing.

M. Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at (5 ft) intervals.

N. Contractor shall install all low voltage communication wiring as per all TIA/EIA communication cabling standards. All cabling shall be installed in dedicated cabling support such as j-hook, d-rings, or saddles. All supports shall be supported directly from building structure. Do not support cabling or supports from ceiling grid wire, conduit, ductwork, piping, or other system cabling. All cabling must be installed in independent support for that given system and may not share supports or run in same conduit or support. All cabling shall be supported every 5’-0” from approved cabling support method. Contractor shall bundle all system cabling and label all wiring for system they serve. All cabling passing thru walls shall require dedicated conduit sleeves with bushing to protect cabling during installation. Contractor shall provide 1 meter service loops at all device termination locations and 3 meter service loops at all head end termination locations. All low voltage HVAC control cabling shall be yellow in color unless specified otherwise. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

O. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

P. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

Q. Include one pull string in each raceway 2.5 cm (1 in.) or larger.

R. Use color-coded conductors throughout.

S. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

T. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 15 cm (6 in.) between raceway and high-temperature equipment such as steam pipes or flues.

U. Adhere to requirements in Division 26 where raceway crosses building expansion joints.

V. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

W. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

X. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft.) in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size.

Y. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.7 COMMUNICATION WIRING

A. Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network's integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

G. Label communication wiring to indicate origination and destination.

H. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.8 FIBER OPTIC CABLE

A. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

3.9 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft. of sensing element for each 1 ft. ^{2} of coil area.

G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall at designated location with sun shield.

I. Differential Air Static Pressure.

1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.

5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

J. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.10 FLOW SWITCH INSTALLATION

A. Adjust flow switch according to manufacturer's instructions.

3.11 ACTUATORS

A. General. Mount actuators and adapters according to manufacturer's recommendations.

B. Electric and Electronic Damper Actuators. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations.

1. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
2. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten linkage.

3. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

4. Provide necessary mounting hardware and linkages for actuator installation.

3.12 IDENTIFICATION OF HARDWARE AND WIRING

A. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.

B. Label pneumatic tubing at each end within 5 cm (2 in.) of termination with a descriptive identifier.

C. Permanently label or code each point of field terminal strips to show instrument or item served.

D. Label control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

E. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

F. Label valves with nameplates.

G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

H. Label identifiers shall match record documents.

3.13 PROGRAMMING

A. Point Naming. Name points as shown on the equipment points list provided with each Sequence of Operation. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

B. All DDC programming shall be accomplished through graphical programming, line code is unacceptable

C. Software Programming. Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented.

1. Application Programming. Provide application programming that adheres to sequences of operation specified in Section 23 09 93. Program documentation or comment statements shall reflect language used in sequences of operation.

2. System Programming. Provide system programming necessary for system operation.

D. Operator Interface.

1. Standard Graphics. Provide graphics as specified in Section 23 09 23 Article 2.3 Paragraph E.2 (System Graphics). Show on each equipment graphic input and output points and relevant calculated points such as indicated on the applicable Points List located in the Sequence of Operation. Point information on graphics shall dynamically update.
2. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation) as described in Section 23 09 23.

3. DDC screen graphic room numbers shall be based on final room graphics package. Obtain Architect/Owner approval of final room numbers prior to programming.

3.14 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.

1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under Section 23 09 23.

2. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.

3. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.

4. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.

5. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.

6. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.

7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.

8. Alarms and Interlocks.

a. Check each alarm with an appropriate signal at a value that will trip the alarm.

b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.

c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

3.15 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration. Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Article 3.15 (Control System Checkout and Testing). Provide Engineer with log documenting completion of startup tests.

1. Preliminary Review: At least 7 days prior to on-site demonstration, provide read-only username and password to Engineer for preliminary system review to be performed remotely. Engineer will review to verify all systems are connected and communicating and all points are reading properly and graphics are complete. The Engineer will provide a report of any deficiencies. The contractor shall correct all deficiencies prior to on-site demonstration.

2. On-site Demonstration: Engineer, Owner, contractor(s) and any/all factory authorized equipment representatives shall be present to perform, observe and review system demonstration. Notify Engineer/Architect at least 10 days before system demonstration is scheduled.

a. Demonstration shall follow process submitted and approved under Section 23 09 23 Article 1.9 (Submittals). Complete approved checklists and forms for each system as part of system demonstration.

b. Demonstrate actual field operation of each sequence of operation as specified in Section 23 09 93. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.

c. Demonstrate compliance with sequences of operation through each operational mode.

d. Demonstrate complete operation of operator interface.

e. Demonstrate each of the following.

f. DDC loop response. Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.

g. Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting setpoint, and status of setpoints and other affected equipment parameters.

h. Building fire alarm system interface.

i. Trend logs for each system. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation in Section 23 09 93. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs as specified in Section 23 09 23 Article 2.3 Paragraph F.11 (Trend Configuration).

3. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

B. Acceptance.

1. After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required in Section 23 09 23 Article 1.9 (Submittals).

3.16 CLEANING

A. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

B. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

C. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

3.17 SUPPLEMENTAL OPERATIONAL SOFTWARE

A. Utility reporting Software

1. Scope of Work: Power monitoring will be accomplished by accessing existing ERCOT grade revenue metering and/or by the installation of a separate power meter/switch gear interface. Write programming for server based data extraction software. Install software onto Web-Access server. Verify and commission program functionality from the central site computer. Utility reporting will monitor and record consumption at user definable increments. Utility reporting will generate reports based on user definable timeframes. Monitoring Data shall be extracted from the server, through the World Wide Web, via xml / SOAP. Data shall be collected at 15-minute intervals. Data shall be assimilated in a user definable format, reflecting, at a minimum, the following values, per building, per user definable time frame:

a. KW

b. KWh

c. Plant run times

d. Outside Air Temperature

2. Facility data shall be input to the database. This data shall be assimilated by the BAS contractor by site survey. Data from drawings or schedules is unacceptable on its own, and must be field verified.

a. Building square footage

b. Building population

c. Current electric utility rate structure

3. Reports shall be generated which configure the data in a user-friendly format. All reports shall be easily sorted to identify excessive energy consumption. User definable alarm thresholds shall be enabled. Data, and alarm thresholds shall be normalized for degree-days. At a minimum, the reports will consist of the following:

a. Budget Report - Comparative analysis of budgeted energy costs versus actual energy costs.

b. Trend Report - Trend KWH for each day of a user defined period. Display in graphic format.

c. Board Report - Data is sorted by the following criteria: facility type, raw KWH, KWH per square foot, cost per square foot, and cost per occupant and plant runtime accumulation.

d. ECM report - Comparative data based on consumption history before, and consumption history after, an Energy Conservation Measure is executed

e. Summary Report - All report data shall be assimilated in this single report.

B. Power Meter Monitoring Service

1. Scope of Work: During the Warranty Period, the BAS contractor will provide a supplemental monitoring service to assure the optimization of the Power Meter Monitoring Service. The Power Meter Monitoring Service shall be continually utilized to identify Energy Conservation Measures. BAS Contractor will apply the following resources to this service:

a. Certified energy Manager (CEM)

b. Engineering and software support

c. Daily inspections from the BAS Contractor help desk

d. Regular field inspections by BAS Contractor technicians

2. Requirements of this contract require the BAS contractor to perform the following requirements.

a. Establish alarming thresholds and building benchmark

b. Receive all alarms if weekly thresholds are exceeded.

c. Perform a regular data extraction.

d. Identify to owner any instances where the alarm threshold has been exceeded.

e. Perform a preliminary analysis and remediate where possible.

f. Continually search for opportunities in the way of energy curtailment measures (ECMs).

g. Publish a monthly report, complete with analysis and recommendation for ECMs, presented in both hardcopy and digital media.

END OF SECTION 23 09 23

SECTION 26 20 00 - ELECTRICAL DISTRIBUTION EQUIPMENT

PART 1 - GENERAL 1

1.0 OWNER FURNISHED CONTRACTOR INSTALLED (OFCI) EQUIPMENT

A. Main Switch Board to be furnished by Owner.

1.1 RELATED DOCUMENTS

A. Conditions of the Contract Documents and Division 01 - General Requirements as applicable, apply to this Section.

1.2 SUMMARY

A. Provide all electrical distribution and motor control equipment and accessories required to distribute electrical power to all motors, outlets and systems requiring power.

1.3 QUALITY ASSURANCE

A. New: Provide all new equipment.

B. Single Manufacturer: All equipment of each type shall be the product of one manufacturer.

C. UL: Equipment shall be UL listed. Service entrance equipment shall bear UL Service Entrance label.

D. CEC: Equipment and installation shall comply with the California Electrical Code.

E. Wet Locations: Equipment and enclosures installed outdoors and in wet locations shall be approved for this purpose.

F. IEEE: Institute of Electrical and Electronics Engineers Standard 1015-1997 (Blue Book) Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.

1.4 LABELING

A. Nameplates and labeling shall be provided in accordance with Section 26 05 53. All feeders shall be labeled on the feeder device.

1.5 FINISHES

A. All equipment shall have a factory applied gray finish applied over a rust inhibiting treatment. Any items which have the finish marred shall be touched up or refinished to a new condition before final acceptance. This shall include, but shall not be limited to, sanding and properly removing rust or other contaminants and completely repainting equipment if damage is extensive. Overall acceptance is subject to approval of the Engineer.

1.6 SUBMITTALS

A. Provide complete product data for each equipment type. Provide electric service studies when required.

B. Submittal shall include written recommendation from manufacturer of settings for all electronic trip adjustment setting on all equipment furnished with adjustable trip settings. Contractor is responsible for adjusting all electronic trip settings per manufacturer recommendations.

C. Electrical connections to all equipment furnished by any other division shall be coordinated with final approved equipment submittals from other divisions including but not limited to circuit breaker sizes, conduit sizes, wire sizes, fuse sizes, disconnect switch sizes and starter sizes that differ from those shown on the drawings prior to submitting Electrical Distribution Equipment submittal.

1.7 SHORT CIRCUIT CURRENT RATINGS

A. General: All switchboards and panelboards shall be fully rated and marked with a maximum short circuit current rating. The equipment manufacturer shall have verified this rating with high-amperage testing. All short circuit current ratings are expressed as amperes RMS symmetrical at the applied voltage unless otherwise noted. All equipment shall withstand the specified level of fault current. All overcurrent devices shall interrupt the specified level of fault current.

1.8 ELECTRIC SERVICE STUDIES

A. Standard: Submit studies in accordance with ANSI/ IEEE Standard 242 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

B. Submit one-line diagram for each electrical service. Key all equipment and components on diagram to items in the studies.

C. Provide a short-circuit current analysis for each main switchboard. Short-circuit analysis shall calculate short-circuit levels at service transformer secondary, switchboard main breaker, each feeder breaker and all levels of downstream distribution equipment. Assume infinite source bus.

D. Provide a time-current coordination study for each main switchboard. Coordination study shall compare the operating levels and times of the protective devices to the withstand levels and times that the equipment can sustain without damage or failure. Determine electronic trip unit settings necessary to achieve optimal selective coordination between 480 volt main service circuit breakers and first level of feeder distribution devices. Determine setting for all adjustments of trip units of all electronic circuit breakers that are linked by zone-selective-interlocking. Furnish time-current curves for the two (or more) levels of distribution protected with electronic trips, plus the first additional distribution level served from the switchboard feeder. Show a separate composite plot for each feeder breaker trip rating with the main breaker. Plot composite time-current curves on log-log background. Add a typical frame size of downstream molded-case circuit breaker to each switchboard feeder composite plot.

E. Provide arc-flash calculation and labeling for equipment in the project.

F. The contractor shall make all adjustments to circuit breakers per electric service study and provide written documentation that all adjustments have been made.

1.9 OWNER'S INSTRUCTION

A. Provide a four-hour period of instruction to the Owner's designated personnel upon completion of the main switchboard’s installation. Review manufacturer’s recommended switchboard maintenance. The Operations and Maintenance Manual shall be complete and on-site at the time of Owner instruction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Unless indicated otherwise, all equipment in this section shall be provided by a single manufacturer. The product designations listed are to establish a level of quality. Acceptable manufacturers are:
   1. Square D.
   2. Siemens.
   3. G.E.
   4. Cutler-Hammer.

2.2 ENCLOSED SWITCHES

A. General: Provide heavy duty enclosed switches similar to Square D Class 3100 Type HD.

B. Switch Interior:
   1. All switches shall have switchblades which are visible when the switch is OFF and the cover is open.
   2. Lugs shall be front removable and UL Listed for 75 degrees Celsius conductors.
   3. All current carrying parts shall be plated to resist corrosion.
   4. Switches shall have removable arc suppressors to facilitate easy access to line side lugs.
   5. Switches shall have provisions for a field installable electrical interlock.

C. Switch Mechanism:
   1. Switch operating mechanism shall be quick-make, quick-break such that, during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing or opening action of the contacts has started.
   2. The operating handle shall be an integral part of the box, not the cover.
   3. Provisions for padlocking the switch in the OFF position with at least three padlocks shall be provided.
   4. The handle position shall travel at least 90 degrees between OFF and ON positions to clearly distinguish and indicate handle position.
   5. All switches shall have a dual cover interlock mechanism to prevent unintentional opening of the switch cover when the switch is ON and prevent turning the switch ON when the cover is open. The cover interlock mechanism shall have an externally operated override, but the override shall not permanently disable the interlock mechanism. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

D. Switch Enclosures:
   1. Switch covers shall be attached with welded pin-type hinges.
   2. The enclosure shall be finished with gray baked enamel paint, which is electrodeposited on cleaned, phosphate pre-treated steel.
   3. The enclosure shall have ON and OFF markings stamped onto the cover.
   4. The operating handle shall be provided with a dual colored, red/ black position indication,
   5. All switches shall have provisions to accept up to three (3) 3/8-inch hasp padlocks to lock the operating handle in the OFF position.
   6. Tangential knockouts shall be provided to facilitate ease of conduit entry.

E. Switch Ratings:
   1. Switches shall be horsepower rated for ac and/ or dc as indicated on the plans.
   2. The UL Listed short circuit current rating of the switches shall be 200,000 rms symmetrical amperes when used with or protected by Class J fuses.
   3. Non-Fusible: 10,000 rms symmetrical amps.

F. Fuse Clips: NEMA FU 1, Class J fuses.

2.3 SINGLE CIRCUIT BREAKERS WITH ENCLOSURES

A. Product Description: Enclosed, molded-case circuit breaker conforming to NEMA AB 1, suitable for use as service entrance equipment where applied.

B. Circuit Breakers: Molded case, quick make, quick break, trip free, common thermal magnetic trip.

C. Ratings: Continuous current, poles as required, 480 volt system breaker shall interrupt short circuits up to 14,000 rms amps symmetrical; on 120/ 208 - 240 volt system, 10,000 amp rms symmetrical.

D. Enclosure: NEMA AB 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.
   1. Interior Dry Locations: Type 1.
   2. Exterior Locations: Type 3R.

E. Nameplate: Provide a nameplate showing load served.

2.4 FRACTIONAL HORSEPOWER MANUAL MOTOR CONTROLLER

A. Square D - Class 2510 Type F:
   1. Description: NEMA ICS 2, ac general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, red pilot light and toggle operator.
   2. Enclosures: ANSI/ NEMA ICS 6, Type as indicated.

2.5 MAGNETIC MOTOR CONTROLLERS

A. Square D - Class 8536 Type S:
   1. Description: NEMA ICS 2, ac general-purpose Class A magnetic controller for induction motors rated in horsepower.
   2. Coil Operating Voltage: Provide as required to interface with controls system, including control power transformer.
   3. Coil: Be of encapsulated type.
   4. Poles: as indicated.
   5. Size: as indicated.
   6. Contacts: Totally enclosed, double-break, silver-cadmium-oxide power contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring.
   7. Wiring: Straight-through wiring with all terminals clearly marked.
   8. Overload Relay: NEMA ICS:
      a. Solid State: Trip current rating will be established by selection of overload relay and shall be adjustable (3 to 1 current range). The overload shall be self-powered. Provide phase loss, phase unbalance protection, permanent tamper guard, Trip Class 10 or 20 and a mechanical test function.
      b. Outputs: Units shall be designed for addition of either a normally open or normally closed auxiliary contact and shall be field convertible. Provide one (1) set of N.O. and N.C. contacts in each starter.
      c. Reset: Unit shall include both manual reset and remote reset using an external module.
      d. Select overload current setting based on the motor nameplate data of the actual motor to be protected. All standard NEMA sizes may be used for the overload relay, including Size 00.
   9. Enclosure: ANSI/ NEMA ICS 6, Type 1, 3R or 4X.

10. Control Power Transformers: 120 volt secondary. VA minimum, in each motor starter. Provide fused primary and secondary.
11. Provide red LED running pilot light and H-O-A switch.

2.6 MAGNETIC MOTOR CONTROLLERS - TWO - SPEED

A. Square D - Class 8810 Type S:
1. Description: Include integral time delay transition between FAST and SLOW speeds. Starters shall be electrically and mechanically interlocked to prohibit both starters being energized simultaneously.
2. Coil operating voltage: Provide as required to interface with controls system, including control power transformer.
3. Coil: Be of encapsulated type.
4. Poles: as indicated.
5. Size: as indicated.
6. Contacts: Totally enclosed, double-break, silver-cadmium-oxide power contacts.
7. Contact inspection and replacement shall be possible without disturbing line or load wiring.
8. Wiring: Straight-through wiring with all terminals clearly marked.
9. Overload Relay: NEMA ICS.
   a. Solid State: Trip current rating will be established by selection of overload relay and shall be adjustable (3 to 1 current range). The overload shall be self-powered. Provide phase loss, phase unbalance protection, permanent tamper guard, Trip Class 10 or 20 and a mechanical test function.
   b. Outputs: Units shall be designed for addition of either a normally open or normally closed auxiliary contact and shall be field convertible. Provide one (1) set of N.O. and N.C. contacts in each starter.
   c. Reset: Unit shall include both manual reset and remote reset using an external module.
   d. Select overload current setting based on the motor nameplate data of the actual motor to be protected. All standard NEMA sizes may be used for the overload relay, including Size 00.
10. Enclosure: ANSI/ NEMA ICS 6, Type 1, 3R or 4X.
11. Two speed motor controllers shall be designed for type of motor winding specified in Division 23 Mechanical Specifications, Drawings, or Equipment Schedule. Coordinate with Division 23 prior to submittal.
12. Provide red-high, amber-low running pilot lights and H-O-L-A switch.
13. Provide two speed motor controllers for all two speed motors specified in Division 23 Mechanical Specifications, Drawings, or Equipment Schedule. Coordinate with Division 23 prior to submittal.

2.7 COMBINATION DISCONNECT/ MOTOR STARTERS

A. Square D - Class 8538 Type S (Fusible or no fuse, as shown on plans):
1. Description: Combine magnetic motor controllers with fusible switch disconnect in common enclosure. The switch shall have a color coded externally operated handle. Operating handle shall give positive visual indication of ON/ OFF with red and black color-coding.
2. Fusible Switch Assemblies: NEMA KS 1, enclosed knife switch with externally operable handle. Fuse clips: Designed to accommodate Class J fuses and visible blades. Operating handle shall give positive visual indication of ON/ OFF with color-coded operating handle.
3. Magnetic Motor Controllers: Refer to paragraph(s) specifying magnetic motor controllers for requirements.

2.8 FUSES (600 VOLTS AND BELOW)

A. Manufacturers:
   1. Bussmann.
   2. Little Fuse.
   3. Ferraz Shawmut.

B. Dimensions and Performance: NEMA FU 1, Class as specified or as indicated on Drawings.

C. Voltage: Rating suitable for circuit phase-to-phase voltage.

D. Class J (Time Delay) Fuses:
   1. Dimensions and Performance: NEMA FU 1.
   2. Voltage: Rating suitable for circuit phase-to-phase voltage.
   3. Dual-element, time delay ten (10) seconds (minimum) at 500 percent rated current.

E. Spares: Spare fuses shall be provided in the amount of ten (10) percent of each type and size installed. Replacement for fuses and limiters blown during construction shall not count as spares.

2.9 DISTRIBUTION PANELBOARDS (OFCI)

A. Product Description: NEMA PB 1, circuit breaker type panelboard.

B. Panelboard Bus: copper current carrying components, ratings as indicated on Drawings. Furnish copper ground bus in each panelboard.

C. Molded Case Circuit Breakers: NEMA AB 1, circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Furnish circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits.

D. Main Circuit Breaker:
   1. When distribution panel has main circuit breaker, provide molded case circuit breaker with electronic trip unit. Current sensing to be true-rms.
   2. Main breaker shall have minimum interrupting rating of 65,000 amperes rms symmetrical at applied voltage.
   3. Electronic trip shall be Square D micrologic with adjustable long-time, short-time and instantaneous pick-up set points.

E. Cabinet Front: Safety dead front type. Conform to NEMA 1; NEMA 3R if located outdoors. All panelboards located in kitchen areas shall be flush mount with NEMA 4X Stainless Steel enclosures.

2.10 BRANCH CIRCUIT PANELBOARDS (OFCI)

A. Product Description: NEMA PB1, circuit breaker type, lighting and appliance branch circuit panelboard.

B. Panelboard Bus: Copper current carrying components, ratings as indicated on Drawings. Furnish copper ground bus in each panelboard.

C. For non-linear load applications subject to harmonics furnish 173 percent rated, plated copper, solid neutral.

D. Minimum Integrated Short Circuit Rating: 10,000 amperes rms symmetrical for 208-240/ 120 volt panelboards; 22,000 amperes rms symmetrical for 480 volt panelboards.

E. Molded Case Circuit Breakers: NEMA AB 1, bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles, listed as Type SWD for lighting circuits, Type HACR for air conditioning equipment circuits, Class A ground fault interrupter circuit breakers as indicated on Drawings. Do not use tandem circuit breakers.

F. Enclosure: NEMA PB 1, Type 1 or Type 3R. All panelboards located in kitchen areas shall be flush mount with NEMA 4X Stainless Steel enclosures.

G. Cabinet Front: Safety dead front type with concealed trim clamps, concealed hinge, metal directory frame, and flush lock keyed alike. Finish in manufacturer's standard gray enamel.

H. Provide ground-fault circuit breaker for each heat trace branch circuit.

I. Panelboards indicated to have thru-feed lugs shall be furnished with thru-feed lugs in all sections of panelboard.

2.11 MAIN SWITCHBOARDS

A. General: Provide universal building–type switchboards fabricated in accordance with NEMA Standard PB–2, UL Standard 891, and bearing a UL Service Entrance Label. Switchboard characteristics are 480/ 277 volts, 3 phase, 4 wire. Main connection and unit-mounted branch connections shall be from the rear. Group mounted branch connections shall be from the front or the rear. The entire switchboard assembly shall be similar to Square D Type QED-2.

B. Structure:
   1. The switchboard shall be freestanding and have front and rear alignment. Provide rear access to main device(s) and all unit-mount branch devices (2000A and less can be front access only). Provide front or rear access to group-mounted devices. Formed up steel channels bolted together to form a rigid structure to which formed up fronts, side sheets, and rear covers are bolted. Galvanized 1–1/2" x 3" mounting channels on bottom, rear, left, and right sides to close all openings at the bottom. Arrange for easy addition of future cubicles at end. Provide pull box, fabricated with unit at factory, on top of switchboard if required for proper entrances and exits of feeders.
   2. When “SPACE” is indicated on one-line diagram, provide full bussing extension to serve that space and all overcurrent device mounting hardware for the given frame size.

C. Installation: Freestanding, level and bolted to a four (4) inch concrete pad.

D. Instrumentation:
   1. General: Monitor the incoming line with a Square D PM 5563 meter with BACnet IP communication port protocol.
   2. Meter shall have digital display adjustable to select phase. Monitor with an ammeter any feeder devices indicated on the Drawings.
   3. Wiring Lugs: Provide ring lugs for all wiring terminations of potential transformers (PTs), current transformers (CTs) and current sensors. Fork lugs are not acceptable. Ring lugs are intended to minimize the chance of leads pulling apart and creating an open circuit. (Zero current reading).

E. Phase, Neutral and Ground Bussing: Silver plated 98% conductivity copper sized to comply with NEMA Temperature Rise Standard. In addition, copper bus shall be sized on the basis of a maximum temperature rise of 65 degree C. The vertical bussing per cubicle shall be sized not less than the sum of all devices, including spare spaces, to be served from that cubicle. **The vertical bus shall be a minimum of 2000 amperes and shall be full height**. Bus supports, connections, and joints shall be bolted with SAE Grade 5 medium carbon steel bolts employing Belleville washers. Provide complete bussing, mounting provisions for circuit protective devices and space screw cover wherever the drawings indicate space only. Arrange and drill bussing for **future full capacity extension**. Provide a full length ground bus, with minimum ampacity of 1/3 phase bus ampacity. Provide full–size neutral rated at 100 percent of phase bus.

F. Terminations: Provide proper incoming line lugs to accommodate cable shown on plans.

G. Short Circuit Ratings:
1. Switchboard assembly of protective devices, together with the bussing and bracing, shall be fully-rated to withstand and interrupt short circuits on a system capable of delivering up to 65,000 (or 100,000) amps RMS symmetrical at nominal system voltage.

H. Provisions for Auto Power Factor Controller (APFC):
1. Provide a circuit breaker with adjustable electronic tripping to protect and disconnect the automatic power factor controller.
2. Set amp trip at minimum 150 percent of ampacity for the actual KVAR installed.
3. Provide buss CTs on main incoming buss for use by the remote auto pf controller. These CTs shall be separate and in addition to all other CTs required for switchboard metering. Install a shorting terminal block on CT until the auto pf controller is installed at the job site.

I. Protective Devices:
1. Switchboard Main Breaker:
   a. Stationary mounted, manually operated, 100 percent rated molded case circuit breakers with electronic tripping system and stored energy closing mechanisms. The electronic tripping system shall be similar to Square D Micrologic Full Function Trip unit. Main breakers shall be Square D NW (3000-4000), [RJ (1600-2500A) 65KA or RL (1600-2500A) 100KA] ampere frame size.
   b. The breaker shall be UL Listed for continuous duty at 100% of the current rating.
   c. Minimum interrupting rating of 65,000 (or 100,000) amperes rms symmetrical at 480/ 277 Volts.
   d. Local trip indicators: overload, short circuit and ground fault.
   e. Electronic sensing systems shall be true-RMS sensing and not susceptible to adverse harmonic current effects.
   f. Adjustments:
      1) The electronic trip unit shall have LSIG Trip functions.
2. Feeder Devices:
   a. Breakers 700 Amps and Larger:
      1) Branch feeder breakers 700 amp and larger shall be molded case circuit breakers rated 100% with electronic trip units, similar to Square D [NW (3000-4000A], [RJ (1600-2500A 65kaic 100%)], [RL (1600-2500A 100kaic 100%)], [PJ (700-1200A 65kaic 100%)], [PL (700-1200A 100kaic 100%)]
      2) Interrupting rating shall be at least 65,000 (or 100,000) amperes rms symmetrical at 480/ 277 Volts.
      3) The electronic trip unit shall have LSI trip functions.
      4) The breaker shall be UL Listed for continuous duty at 100% of the current rating.

b. Breakers 600 amps and smaller shall be type L (600A and 400A frame), J (250A frame), and H (150A frame) molded circuit breakers, AIC rating to match main breaker.
c. The breaker shall be UL Listed for continuous duty at 100% of the current rating.

J. Transient Voltage Surge Suppressor (TVSS):
1. General: Provide a Square D Class 1310 240kA surge current rated mounted in the switchboard mounted above the main circuit breaker compartment.

K. Lightning and Overvoltage Surge Arrester:
1. General: Provide a Square D SDSA3650 lightning and overvoltage surge arrester inside the switchboard housing, connected between the service entrance bussing and the ground bus.
2. Description: Device shall be a heavy duty, three–phase, zinc metal oxide varistor (MOV), secondary class arrester rated for 650 volts and U.L. listed in Category (OWHX) of the Electrical Construction Materials Directory (Green Book). Device shall comply with ANSI/ IEEE C62.11-1987 Standard for Metal Oxide Surge Arresters for AC Power Circuits.
3. Installation shall comply with CEC Article 280. Provide fusing if required by installation instructions from arrester manufacturer.

L. Identification:
1. General: Identify each device and meter with a nameplate showing load served. Refer to Article on LABELING in Section 26 05 00.
2. Master Nameplate: Provide a master nameplate on face of boards similar to following, with correct data shown:

Main Switchboard_____
480/ 277 Volts, 3 Phase, 4 Wire, 60 Hertz
Main Bus:___amps. braced for___ RMS sym. amps.
Date Installed:____

M. Submittal: Include at least the following:
1. Manufacturer and Model Numbers.
2. Dimensions.
3. Cable Termination Provisions.
4. Current Ratings.
5. Voltage Ratings.
6. Short Circuit Ratings.
7. Protective Device Ratings.
8. Electronic metering system.
9. Surge Arrester.
10. Unit Elevation.
11. Bussing Schematic, Sizes and Statement of Conductor and Plating Materials.
12. Original Manufacturer Brochure and Specifications.
13. Coordination drawing using dimensions of actual switchboard submitted. Show board footprint, proper clearances, and other equipment in same room.

N. Testing: Test all devices and systems to ensure proper operation.

2.12 ROOF MOUNTED PEDESTALS

A. Roof Utility Pedestal with 20 Amp GFCI/ Weatherproof receptacle - Provide MAPA Products utility roof pedestal #MPX-20G: 36/ 12.

B. Roof Pedestal with Non-Fused Disconnect Switch and 20 Amp GFCI/ Weatherproof receptacle - Provide MAPA Products roof pedestal. See plans for disconnect sizes.

PART 3 - EXECUTION

3.1 MOUNTING

A. General: All equipment shall be securely fastened in place.

B. Locations: In all cases mounting locations shall comply with the requirements of the California Electrical Code. This shall include providing suitable working clearances.

C. Concrete Pads:
1. Provide concrete in accordance with the Division of the Specifications for that product.
2. Indoor concrete pads shall consist of a four (4) inch pad with beveled edges extending two (2) inches beyond the perimeter of supported equipment. Switchboards, motor control centers, transformers greater than 15 KVA, and engine generators shall be installed on a pad. Refer to the drawings and the specifications for each piece of equipment to determine what other equipment shall be mounted on a pad.
3. All equipment, ground mounted outdoors, shall be mounted on a pad. Outdoor pads shall be minimum of one foot thick reinforced with #4 rebar one (1) foot on center each way. Size outdoor pads with at least four (4) feet working clearance in front of equipment and one (1) foot on all sides. Provide anchor bolts for pad-mounted equipment. Refer to Detail on drawings.

A. Wall Mounted Equipment: Wall mounted equipment shall be suitably positioned on the wall. Equipment mounted on the exterior basement wall shall have unistrut channels between the wall and the equipment to prevent condensation problems. Where wall mounted equipment is specified, but a convenient wall not available, a suitable unistrut mounting stanchion anchored in concrete shall be provided. In lieu of this stanchion, small devices may be mounted on to the equipment served if approved by the equipment manufacturer.

B. Motor rated disconnects: Install disconnects in a vertical orientation with off in the down position.

3.2 DELIVERY, STORAGE AND HANDLING

A. General:
1. Store all types of electrical power distribution equipment in a clean, heated building affording appropriate physical protection. Control access to prevent unauthorized tampering with the equipment. However, equipment may be stored in other inside or outside environments under approved conditions.
2. Inspect equipment when received at Project site for shipping damage. Report as required by freight carrier to recover repair or replacement costs from the freight carrier in the event damage was sustained.
3. Covers are required unless indoor, ventilated storage conditions exist. Canvas tarpaulins or the equivalent are preferred over other coverings because they provide better humidity control and enclosure scuff protection. Where exposed to moisture, covers shall be waterproof.
4. The manufacturer's shipping skids shall be left on the equipment to provide structural support until the equipment is set in the final resting place.
5. Refer to Section 26 05 00 for additional requirements. Contractor shall furnish new equipment to replace any equipment that is exposed to weather or subjected to other deleterious effects of construction.

B. Approved Conditions for Equipment Storage:
   1. General: Where storage conditions specified above are not available, indoor or outdoor storage shall comply with the following.
   2. Switchboards, Motor Control and Other General Distribution and Utilization Equipment:
      a. Store metal-enclosed equipment in an upright position. Provide good ventilation of the shelter and protection from dirt, moisture and physical damage.
      b. Space heaters furnished with the equipment shall be connected to a continuous source of power of the proper rating. Where space heaters are supplied from auxiliary power transformers, care shall be taken that low-voltage heater circuits are properly isolated before power source connection to prevent inadvertent energizing of the auxiliary transformer and associated high-voltage primary wiring.
      c. Ambient conditions may allow condensation inside waterproof covers. If condensation is occurring, temporary heaters or lamp banks shall be provided of sufficient wattage to prevent condensation.
      d. Contractor shall ensure that equipment stored in shipping cases receives adequate ventilation to avoid mildew and prevent condensation.

C. Transformer
   1. Indoor storage shall be provided for all transformers.

3.3 GROUND FAULT PROTECTION OF EQUIPMENT

A. General: Provide for system performance testing as required by the California Electrical Code. Provide each ground fault relay, sensing device or ground fault protection system with instructions and a test form. The form shall be retained by those in charge of the building's electrical installation and be available to the authority having jurisdiction. The instruction content shall be as required by UL.

3.4 LABELING

A. Nametag: Provide a nametag for each piece of distribution equipment; see Section 26 05 53, Electrical Identification.

END OF SECTION 26 20 00

OUTDOOR HEAT PUMP/CONDENSING UNIT SCHEDULE

UNIT NO.	MANUFACTURER AND MODEL NO.	INDOOR UNIT SERVING	COOLING CAP. (MBH) COOLING (TOTAL)	COOLING CAP. (MBH) HEATING (@17°F AMB. WB)	COP2 (@17°F AMB. WB)	AMB.°F	E.E.R.	ELECTRICAL COMPRESSOR QTY.	COMPRESSOR RLA	COMPRESSOR LRA	OUTDOOR FAN QTY.	OUTDOOR FAN FLA	MCA	MOCP	VOLTAGE	OPER WT. (LBS)	ANCHORAGE DETAIL	REMARKS
HP A-1	TOSHIBA/CARRIER MMY-UP0401HT9P	FC A-1 TO FC A-6	240.0	270.0	3.88	88.0 DB 68.0 WB	11.2	2	-	-	1	-	51.5 + 36.6 = 88.1	70 + 45 = 115	230V / 3Ø / 60HZ	725 + 521 = 1246	20 M6.02	SEE NOTES #1-11
HP B-1	TOSHIBA/CARRIER MMY-UP2641HT9P	FC B-1 TO FC B-5	264.0	297.0	3.82	88.0 DB 68.0 WB	10.3	2	-	-	1	-	57.4 + 36.6 = 94.0	80 + 45 = 125	230V / 3Ø / 60HZ	778 + 521 = 1299	20 M6.02	SEE NOTES #1-11
HP C-1	TOSHIBA/CARRIER MMY-UP0401HT9P	FC C-1 TO FC C-4	240.0	270.0	3.88	88.0 DB 68.0 WB	11.2	2	-	-	1	-	51.5 + 36.6 = 88.1	70 + 45 = 115	230V / 3Ø / 60HZ	725 + 521 = 1246	20 M6.02	SEE NOTES #1-11
HP D-1	TOSHIBA/CARRIER MMY-UP0401HT9P	FC C-1 TO FC D-4	240.0	270.0	3.88	88.0 DB 68.0 WB	11.2	2	-	-	1	-	51.5 + 36.6 = 88.1	70 + 45 = 115	230V / 3Ø / 60HZ	725 + 521 = 1246	20 M6.02	SEE NOTES #1-11
HP K-1	AAON CFA-004-A-A-8-L J00H	FC K-1	45.1	40.3	3.88 COP	88.0 DB 68.0 WB	12.6	1	16.7	-	1	2.8	24	40	208V / 3Ø / 60HZ	565	6 M6.01	SEE NOTES #1-11

NOTES:
1. PROVIDE CRANKCASE HEATER, HIGH & LOW PRESSURE SWITCHES.
2. PROVIDE LOW AMBIENT KIT.
3. PROVIDE 3/4" EXPAND METAL CONDENSING COIL GUARD.
4. PROVIDE MINIMUM CLEARANCE AROUND EACH UNIT PER THE MANUFACTURER'S RECOMMENDATIONS.
5. SIZE REFRIGERANT LINES PER MANUFACTURER'S RECOMMENDATIONS. PROVIDE LONG LINE KIT IF REQUIRED.
6. PROVIDE HAIL-GUARD.
7. INSTALL UNIT ON 6" CONCRETE PAD.
8. GROUND MOUNT HEAT PUMP UNIT.
9. ALL UNITS SHALL BE R-410 REFRIGERANT.
10. PROVIDE ALL OUTDOOR HEAT PUMP WITH FACTORY APPLIED ANTI-CORROSION COATING FOR COASTAL INSTALLATION APPLICATIONS.
11. ALL UNITS SHALL BE OWNER FURNISHED CONTRACTOR INSTALLED (OFCI).

FANS SCHEDULE

UNIT	MANUFACTURER & MODEL NO.	SERVICE	TYPE	CFM	SP IN W.G.	FAN RPM	MOTOR HP BHP	MOTOR FLA	MOTOR MCA	MOTOR MOCP	MOTOR DRIVE	MOTOR VOLT	MOTOR PH	MOTOR HZ	SONES	OPER WT. (LBS)	ANCHORAGE DETAIL	REMARKS
EF A-1	GREENHECK CSP-A510-VG	BLDG. "A" GIRL'S TOILET A-5	INLINE	350	0.5	1190	83 WATTS	2.45	-	-	DIRECT	115	1	60	6.6	55	19 M6.02	SEE NOTES #1, 2, 3, 4.
EF A-2	GREENHECK CSP-A390-VG	BLDG. "A" CUSTODIAN STORAGE A-6	INLINE	150	0.3	1007	21 WATTS	1.5	-	-	DIRECT	115	1	60	5	35	19 M6.02	SEE NOTES #1, 2, 3, 4.
EF B-1	GREENHECK CSP-A390-VG	BLDG. "B" BOY'S TOILET B-5	INLINE	150	0.3	1007	21 WATTS	1.5	-	-	DIRECT	115	1	60	5	35	12 M6.02	SEE NOTES #1, 2, 3, 4.
EF C-1	GREENHECK	BLDG. "C" GIRLS RR C-5	INLINE	210	0.5	-	- -	-	-	-	DIRECT	115	1	60	-	-	19 M6.02	SEE NOTES #1, 2, 3, 4.
EF C-2	GREENHECK CSP-A390-VG	BLDG. "C" CUST STORAGE C-6	INLINE	150	0.3	1007	21 WATTS	1.5	-	-	DIRECT	115	1	60	5	35	19 M6.02	SEE NOTES #1, 2, 3, 4.
EF D-1	GREENHECK CSP-610-VG	BLDG. "D" BOY'S TOILET D-5	INLINE	630	0.5	1250	120 WATTS	2.70	-	-	DIRECT	115	1	60	7.2	70	19 M6.02	SEE NOTES #1, 2, 3, 4.
EF K-1	GREENHECK SP-A125	BLDG. "K" UNISEX TOILET K-5	CEILING	100	0.25	1056	18 WATTS	0.18	-	-	DIRECT	115	1	60	0.6	35	12 M6.02	SEE NOTES #1, 3, 4, 6, 7, 8, 9.
EF K-2	GREENHECK SP-A125	BLDG. "K" UNISEX TOILET K-5	CEILING	100	0.25	1056	18 WATTS	0.18	-	-	DIRECT	115	1	60	0.6	35	12 M6.02	SEE NOTES #1, 3, 4, 6, 7, 8, 10.
SF K-1	GREENHECK SP-A125	BLDG. "K" UNISEX TOILET K-5	CEILING	100	0.25	1056	18 WATTS	0.18	-	-	DIRECT	115	1	60	0.6	35	12 M6.02	
SF A/B-1	GREENHECK SQ-160-VG	BLDG. "A" & "B"	INLINE	2760	1.0	1555	3/4 / 0.44	8.8	11	20	DIRECT	115	1	60	12.1 INLET 9.7 RADIATED	70	19 M6.02	SEE NOTES #1, 2, 3, 4, 5, 11.
SF C/D-1	GREENHECK SQ-160-VG	BLDG. "C" & "D"	INLINE	2760	1.0	1555	3/4 / 0.44	8.8	11	20	DIRECT	115	1	60	12.1 INLET 9.7 RADIATED	70	19 M6.02	SEE NOTES #1, 2, 3, 4, 5, 12.

NOTES:
1. PROVIDE BUILT-IN FACTORY MOUNTED AND WIRED DISCONNECT SWITCH.
2. PROVIDE BACKDRAFT DAMPER.
3. INTERLOCK FAN 'S OPERATION WITH TIMKE CLOCK SCHEDULE PROVIDED BY THE SCHOOL DISTRICT.
4. PROVIDE FACTORY SOLID STATE SPEED CONTROLLER MOUNTED WITHIN THE FAN CASING.
5. PROVIDE FAN WITH MERV 13 FILTER BOX.
6. PROVIDE WITH FACTORY INTEGRAL BACKDRAFT DAMPER.
7. PROVIDE WITH HANGING KIT.
8. PROVIDE WITH ROUND DUCT CONNECTOR.
9. INTERLOCK FAN'S OPERATION WITH FAN COIL UNIT FC-K-1.
10. INTERLOCK FAN'S OPERATION WITH FAN COIL UNIT FC-K-2.
11. INTERLOCK FAN'S OPERATION WITH FAN COIL UNITS FC-A-1, FC-A-2, FC A-3, FC-A-4, FC-A-5, FC-A-6, FC-B-1, FC-B-2, FC-B-3 AND FC-B-4.
12. INTERLOCK FAN'S OPERATION WITH FAN COIL UNITS FC-C-1, FC-C-2, FC C-3, FC-C-4, FC-D-1, FC-D-2, FC-D-3 AND FC-D-4.

INDOOR FAN COIL UNIT SCHEDULE

UNIT NO.	MANUFACTURER AND MODEL NO.	SERVICE	LOCATION	TYPE	CAPACITY (MBH) COOLING (TOTAL/ SENSIBLE)	CAPACITY (MBH) HEATING (@17°F AMB. WB)	OSA TEMP. (°F) (DB/WB)	EAT. (°F) (DB/WB)	LAT. (°F) (DB/WB)	SUPPLY FAN MAX. CFM	SUPPLY FAN E.S.P. (IN.)	SUPPLY FAN H.P./ B.H.P.	SUPPLY FAN MAX. B.H.P.	SUPPLY FAN RPM.	ELECTRICAL VOLTAGE	ELECTRICAL UNIT MCA	ELECTRICAL MOCP	OPER. WT. (LBS.)	MIN. OSA (CFM)	ANCHORAGE DETAIL	REMARKS
FC A-1	TOSHIBA/CARRIER MMDD-UB0121VHN-UL	OFFICE A-7	BLDG. "A"	VRF INDOOR	12.0	13.5	88.0/68.0	80.0	67.0	424	0.4	73 WATTS	-	-	208V/ 1Ø / 60HZ	4	6	60	30	25 M6.01	SEE NOTES 1-8, 11.
FC A-2	TOSHIBA/CARRIER MMDD-UB0121VHN-UL	OFFICE A-8	BLDG. "A"	VRF INDOOR	12.0	13.5	88.0/68.0	80.0	67.0	424	0.4	73 WATTS	-	-	208V/ 1Ø / 60HZ	4	6	60	30	25 M6.01	SEE NOTES 1-8, 11.
FC A-3	TOSHIBA/CARRIER MMDD-UB0361VHN-UL	SPEECH THERAPY A-1	BLDG. "A"	VRF INDOOR	36.0	40.0	88.0/68.0	80.0	67.0	923	0.6	241 WATTS	-	-	208V/ 1Ø / 60HZ	5	6	65	75	25 M6.01	SEE NOTES 1-8, 11.
FC A-4	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM A-2	BLDG. "A"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	345	25 M6.01	SEE NOTES 1-8, 11.
FC A-5	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM A-3	BLDG. "A"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	345	25 M6.01	SEE NOTES 1-8, 11.
FC A-6	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM A-4	BLDG. "A"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	345	25 M6.01	SEE NOTES 1-8, 11.
FC B-1	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	LIBRARY B-1	BLDG. "B"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	345	25 M6.01	SEE NOTES 1-8, 11.
FC B-2	TOSHIBA/CARRIER MMDD-UB0721VHN-UL	COMPUTER LAB B-2	BLDG. "B"	VRF INDOOR	72.0	81.0	88.0/68.0	80.0	67.0	2,235	1.0	0.54 KW	-	-	208V/ 1Ø / 60HZ	5.7	15	225	345	25 M6.01	SEE NOTES 1-8, 11.
FC B-3	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM B-3	BLDG. "B"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	345	25 M6.01	SEE NOTES 1-8, 11.
FC B-4	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM B-4	BLDG. "B"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	345	25 M6.01	SEE NOTES 1-8, 11.
FC B-5	TOSHIBA/CARRIER MMDD-UB0121VHN-UL	OFFICE B-6	BLDG. "B"	VRF INDOOR	12.0	13.5	88.0/68.0	80.0	67.0	424	0.4	73 WATTS	-	-	208V/ 1Ø / 60HZ	4	6	60	30	25 M6.01	SEE NOTES 1-8, 11.
FC C-1	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM C-1	BLDG. "C"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC C-2	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM C-2	BLDG. "C"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC C-3	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM C-3	BLDG. "C"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC C-4	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	SPECIAL ED CLASSROOM C-4	BLDG. "C"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC D-1	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM D-1	BLDG. "D"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC D-2	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM D-2	BLDG. "D"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC D-3	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	CLASSROOM D-3	BLDG. "D"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC D-4	TOSHIBA/CARRIER MMDD-UB0601VHN-UL	SPECIAL ED CLASSROOM D-4	BLDG. "C"	VRF INDOOR	60.0	67.0	88.0/68.0	80.0	67.0	1,728	0.6	519 WATTS	-	-	208V/ 1Ø / 60HZ	7	10	85	-	25 M6.01	SEE NOTES 1-8, 11.
FC K-1	AAON V3-ARB-9-0-461C	KINDERGARTEN K-1, K-2, WORK RM K-3	BLDG. "K"	DOAS INDOOR	45.1/35.1	40.3	88.0/68.0	88.0/68.0	51.0/50.5	900	0.7	-/0.62	2.4	2439	208V/ 1Ø / 60HZ	6	15	425	900	16 M6.01	SEE NOTES 1-4, 8, 9, 10, 11.

NOTES:
1. PROVIDE WITH CONDENSATE DRAIN PAN (PRIMARY AND SECONDARY) FOR FAN COIL UNIT AND ASSOCIATED PIPING.
2. PROVIDE ALL CONDENSATE DRAIN LIFT PUMP (CONDENSATE PUMP SHALL BE POWERED THRU INDOOR FAN COIL UNIT).
3. SIZE REFRIGERANT LINES PER MANUFACTURER'S RECOMMENDATIONS.
4. PROVIDE FACTORY T-24 COMPLIANT PROGRAMMABLE THERMOSTAT WITH "COOLMASTER" INTERFACE FOR BACNET, AND AIR-THINGS CO2 MONITOR.
5. SUSPENDED HORIZONTAL MOUNT UNIT.
6. UNIT WITH STEP DOWN TRANSFORMER. INTERLOCK UNIT WITH OSA & RA MOTORIZED DAMPERS. SEE MOTORIZED DAMPER SCHEDULE THIS SHEET.
7. UNIT SHALL HAVE DUCT FLEX CONNECTIONS INSTALLED ON HORIZONTAL DUCTS.
8. ALL UNITS SHALL HAVE R-454B REFRIGERANT.
9. VERTICAL, FLOOR MOUNT UNIT.
10. PROVIDE UNIT WITH MERV 13 FILTER.
11. ALL UNITS SHALL BE OWNER FURNISHED CONTRACTOR INSTALLED (OFCI).

AIR DISTRIBUTION SCHEDULE

SYMBOL	TYPE	MAKE & MODEL	DESCRIPTION
A	CEILING SUPPLY	TITUS MODEL MCD-3	MODULAR CORE DIFFUSER WITH FRAME FOR LAY-IN T-BAR CEILING, FLUSH FACE MOUNTING.
B	CEILING RETURN	TITUS MODEL PAR-3	PERFORATED FACE DIFFUSER WITH FRAME FOR LAY-IN T-BAR CEILING, FLUSH FACE MOUNTING.
C	CEILING SUPPLY	TITUS MODEL MCD-1	MODULAR CORE DIFFUSER WITH RAPID MOUNT FRAME MODEL TRM FOR SURFACE MOUNTING.
D	CEILING RETURN/EXHAUST	TITUS MODEL 50F	EGG CRATE GRILLE DIFFUSER WITH RAPID MOUNT FRAME MODEL TRM FOR SURFACE MOUNTING.
E	SIDEWALL SUPPLY/RETURN	TITUS MODEL 1700	DOUBLE DEFLECTION HORIZONTAL 5° DOWN FRONT GRILLE WITH 1/2" BLADE SPACING AND OBD, FOR DUCT/WALL MOUNTING.
F	CEILING SUPPLY	TITUS MODEL ML-3B-2B	ALUMINUM LINEAR SLOT DIFFUSER, 3/4" SLOT-4-SLOT, PATTERN CONTROLLER, FLANGED BORDER FOR SURFACE MOUNTING, OPTIONAL PLENUM IN 2,3,4 OR 5 FOOT SECTIONS PER PLANS, COLOR PER ARCHITECT.

NOTES:
1. EQUIVALENT MODELS OF KRUEGER, ANEMOSTAT, PRICE OR T&B ARE ACCEPTABLE.
2. REFER TO THE FLOOR PLANS FOR NECK SIZE, CFM, AIR DIFFUSION PATTERN AND FIRE/DAMPER, IF REQUIRED.
3. PROVIDE AIR CONTROL GRID FOR ALL CEILING SUPPLY DIFFUSERS SET AT 90°.
4. INTERIOR OF ALL GRILLES SHALL BE PAINTED FLAT BLACK.

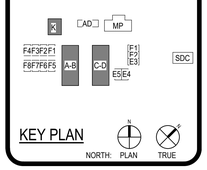
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WILLMORE ES HVAC UPGRADE & MODERNIZATION

PROJECT ADDRESS: 7122 Maple St. Westminster, CA 92683

100% CONSTRUCTION DOCUMENTS

DSA APPL NO.: 04-121971 DSA FILE NO.: 30-43



Consultant

REGISTERED PROFESSIONAL ENGINEER REX DAVID WANG No.M36155 Exp.09-30-2026 MECHANICAL STATE OF CALIFORNIA

Architect

LICENSED ARCHITECT Yong Yoo No. C-31162 REN. 10-31-2027 STATE OF CALIFORNIA

CLIENT
WESTMINSTER SCHOOL DISTRICT

DATE	PROJECT NUMBER
11-14-2025	250377

REVISIONS

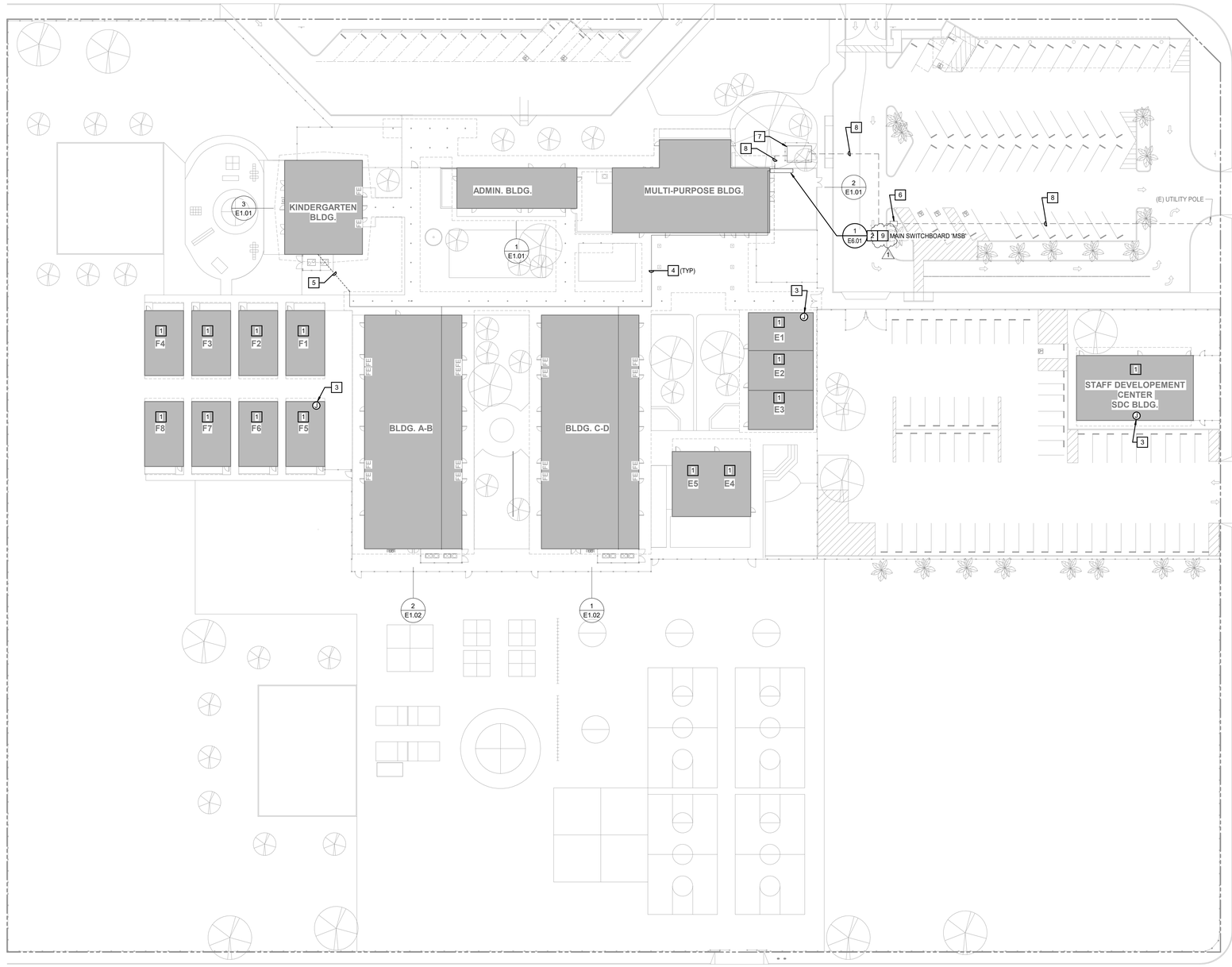
No.	Description	Date
1	Addendum 1	04/27/2026

100% CONSTRUCTION DOCUMENTS

MECHANICAL SCHEDULES

M5.01

0" 1"



GENERAL NOTES

1. COORDINATE ROUTING FOR ALL UNDERGROUND ELECTRICAL BRANCH CIRCUITS AND FEEDERS WITH OTHER DISCIPLINES PRIOR TO TRENCHING.
2. UNLESS NOTED OTHERWISE ALL UNDERGROUND CONDUIT SHOWN ON THIS PLAN TO BE MINIMUM 1" IN SIZE.
3. CONTRACTOR SHALL BE RESPONSIBLE FOR ANY DAMAGE TO EXISTING UTILITIES CAUSED BY INSTALLATION OF NEW WORK.

KEY NOTES

1. BUILDING NOT IN SCOPE, UNO.
2. EXTEND EXISTING FEEDER(S) FROM EXISTING POWER TO REPLACED EQUIPMENT SHOWN.
3. PROVIDE CONNECTION FOR FIRE ALARM POWER SUPPLY AND AMPLIFIER. CONNECT TO PANEL SERVING THIS PORTABLE/BUILDING. PROVIDE RED LOCK-ON CIRCUIT BREAKER.
4. FEEDERS SHALL BE RAN ALONG ROOF SURFACE FROM POWER SOURCE.
5. FEEDERS SHALL BE RAN ALONG ROOF SURFACE FROM POWER SOURCE, THEN DOWN, ROUTED UNDERGROUND TO EQUIPMENT INDICATED.
6. PROVIDE 3' x 5' PULLBOX, PER UTILITY REQUIREMENTS.
7. PROVIDE CONCRETE TRANSFORMER PAD, PER UTILITY REQUIREMENTS. COORDINATE SIZE AND LOCATION WITH UTILITY COMPANY PRIOR TO START OF WORK .

   TRANSFORMER CLEARANCE REQUIREMENTS SHALL BE AS FOLLOWS:
   - FRONT - 8'-0"
   - SIDES - 3'-0"
8. CONTRACTOR SHALL TRENCH AS REQUIRED AND PROVIDE PRIMARY AND SECONDARY CONDUITS, PER UTILITY REQUIREMENTS. BACKFILL AND PATCH EXISTING FINISHES.
9. EQUIPMENT TO BE OFCI (OWNER FURNISHED, CONTRACTOR INSTALLED).

1 ELECTRICAL SITE PLAN
1" = 30'-0"

PBK

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WILLMORE ES HVAC UPGRADE & MODERNIZATION

PROJECT ADDRESS:
7122 Maple St.
Westminster, CA 92683

100% DESIGN DEVELOPEMENT

DSA APPL NO.: 04-121616 DSA FILE NO.: 30-43

K AD MP
F4F3F2F1 F8F7F6F5 A-B C-D E5E4 F1 F2 E3 SDC

KEY PLAN
NORTH: PLAN TRUE

Consultant

REGISTERED PROFESSIONAL ENGINEER STEVEN C. MOSER No. E-19817 Exp. 3-31-26 ELECTRICAL STATE OF CALIFORNIA

Architect

LICENSED ARCHITECT Tong Yao No. C-31162 REN. 10-31-2027 STATE OF CALIFORNIA

CLIENT
WESTMINSTER SCHOOL DISTRICT

DATE	PROJECT NUMBER
09-30-2025	250377

REVISIONS

No.	Description	Date
1	ADDENDUM 1	04/27/2026

100% DESIGN DEVELOPEMENT

ELECTRICAL SITE PLAN

E0.01

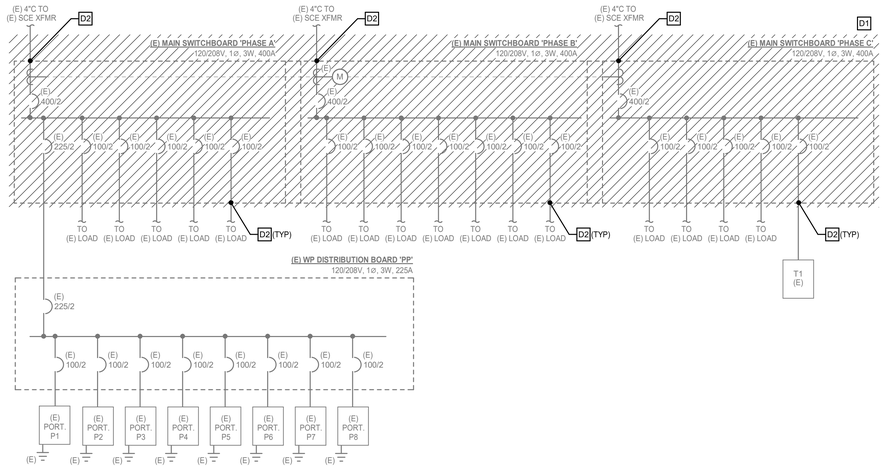
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0" 1"

DEMOLITION KEY NOTES

D1 DEMOLISH AND REMOVE EXISTING EQUIPMENT INDICATED.

D2 CAP EXISTING FEEDERS FOR RECONNECTION IN RENOVATION PHASE.



1 SINGLE LINE DIAGRAM - DEMOLITION
NOT TO SCALE

VOLTAGE DROP CALCULATIONS - FEEDERS

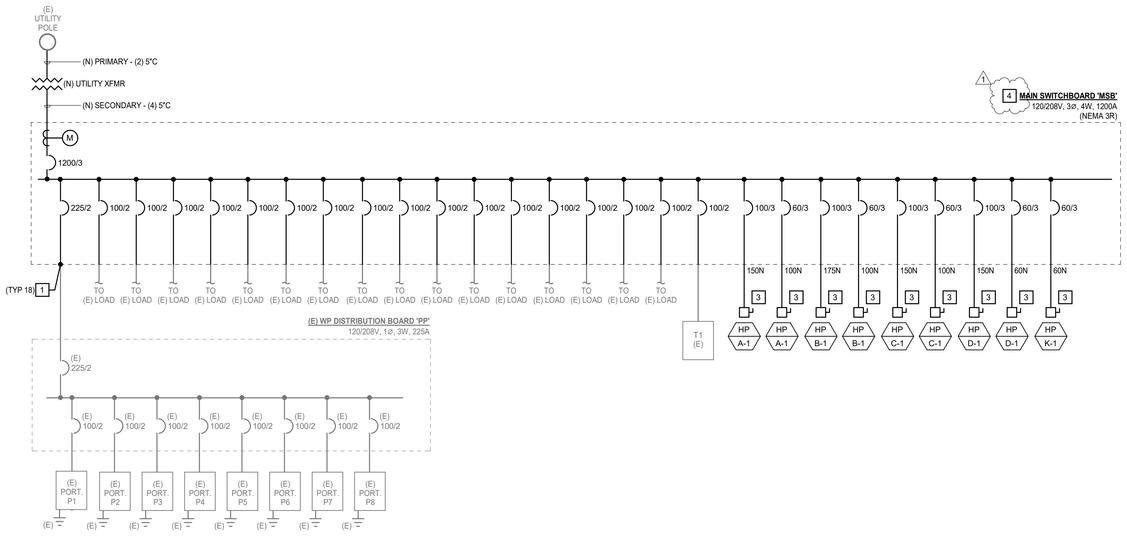
FEEDER	VOLTS	PHASE	AMPS	LENGTH (ft)	SETS	CONDUIT	AMPS/ SET	WIRE	GND	Z @0.85pf	VD(L-N)	VD(L-L)	VD%(L-L)
DPB	208	3								#N/A	#N/A	#N/A	#N/A
HP A-1	208	3	52	500	(1)	2" C.	52	4 # 1/0	6	0.13	3.3	5.8	2.79%
HP A-1	208	3	37	500	(1)	1-1/2" C.	37	4 # 1	8	0.16	3.0	5.1	2.46%
HP B-1	208	3	57	500	(1)	2" C.	57	4 # 2/0	6	0.11	3.2	5.5	2.63%
HP B-1	208	3	37	500	(1)	1-1/2" C.	37	4 # 1	8	0.16	3.0	5.1	2.46%
HP C-1	208	3	52	393	(1)	2" C.	52	4 # 1/0	2	0.13	2.7	4.6	2.21%
HP C-1	208	3	37	393	(1)	1-1/2" C.	37	4 # 3	8	0.23	3.3	5.8	2.78%
HP D-1	208	3	52	393	(1)	1-1/2" C.	52	4 # 1/0	8	0.13	2.7	4.6	2.21%
HP D-1	208	3	37	393	(1)	1-1/2" C.	37	4 # 3	8	0.23	3.3	5.8	2.78%
HP K-1	208	3	37	420	(1)	1-1/2" C.	37	4 # 2	6	0.19	3.0	5.1	2.46%
HP K-2	208	3	37	420	(1)	1-1/2" C.	37	4 # 2	6	0.19	3.0	5.1	2.46%

Switchboard: MSB 4

Supply From: EXISTING XFMR
Mounting: GROUND
Enclosure: NEMA-3R
Volts: 208Y/120V, 3PH, 4W
Phases: 3
Wires: 4
A.I.C. Rating: 65 KAIC
Mains Type: 1200 A
Mains Rating: 1200 A

Circuit Description	Load	Remarks
EXISTING LOAD	0 VA	
(E) PANEL K	2905 VA	
(E) PANEL A	500 VA	
(E) PANEL C1A	5361 VA	
(E) PANEL C2A	5841 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
EXISTING LOAD	0 VA	
HP-A-1	18553 VA	
HP-A-1	13185 VA	
HP-B-1	20679 VA	
HP-B-1	13185 VA	
HP-C-1	18553 VA	
HP-C-1	13185 VA	
HP-D-1	18553 VA	
HP-D-1	13185 VA	
HP-K-1	8646 VA	
	152331 VA	
	423 A	

Load Classifications:	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Motor	137724 VA	100.00%	137724 VA		
Other	11947 VA	100.00%	11947 VA	**Total Conn. Load:**	152331 VA
Receptacle	2160 VA	100.00%	2160 VA	**Total Est. Demand:**	152331 VA
Spare	500 VA	100.00%	500 VA	**Total Conn. Current:**	423 A
				Total Est. Demand Current:	423 A



2 SINGLE LINE DIAGRAM - RENOVATION
NOT TO SCALE

KEY NOTES

1 EXTEND EXISTING FEEDER(S) TO NEW EQUIPMENT SHOWN.

2 NEW CIRCUIT BREAKER, NEW LOAD. MANUFACTURER AND AIC RATING TO MATCH EXISTING.

3 REFER TO EQUIPMENT CONNECTION SCHEDULE POWER PLANS FOR DISCONNECT AND FEEDER SIZE.

4 EQUIPMENT TO BE OFCI (OWNER FURNISHED, CONTRACTOR INSTALLED).

FEEDER SCHEDULE

TAG NUMBER	CONDUCTOR QUANTITY AND SIZE	CONDUIT SIZE	SETS
30N	4#10, 1#10G	1"	1
50N	4#6, 1#10G	1"	1
60N	4#6, 1#10G	1"	1
100	3#1, 1#6G	1 1/2"	1
100N	4#1, 1#6G	1 1/2"	1
125	3#1, 1#6G	1 1/2"	1
125N	4#1, 1#6G	2"	1
150	3#1/0, 1#6G	1 1/2"	1
150N	4#1/0, 1#6G	2"	1
175	3#2/0, 1#6G	2"	1
175N	4#2/0, 1#6G	2"	1
200	3#3/0, 1#6G	2"	1
200N	4#3/0, 1#6G	2"	1
225	3#4/0, 1#4G	2"	1
225N	4#4/0, 1#4G	2 1/2"	1
250	3#250, 1#4G	2 1/2"	1
250N	4#250, 1#4G	3"	1
300	3#350, 1#4G	3"	1
300N	4#350, 1#4G	3"	1
400	3#3/0, 1#3G	2"	2
400N	4#3/0, 1#3G	2"	2
400S	4#500	3 1/2"	1
600	3#350, 1#1G	3"	2
600N	4#350, 1#1G	3"	2
600S	4#350	3"	2
800	3#500, 1#1/0G	3"	2
800N	4#500, 1#1/0G	3 1/2"	2
800S	4#500	3 1/2"	2
1000	3#400, 1#2/0G	3"	3
1000N	4#400, 1#2/0G	3"	3
1000S	4#400	3"	3
1200	3#350, 1#3/0G	3"	4
1200N	4#350, 1#3/0G	3"	4
1200S	4#350	3"	4
1600S	4#400	3"	5
2000S	4#400	3"	6
2500S	4#500	3 1/2"	7
3000S	4#500	3 1/2"	8
4000S	4#500	3 1/2"	11

ELEC. SERVICE LOAD SUMMARY

LOAD DESCRIPTION	ESTIMATED DEMAND KVA
EXISTING PEAK DEMAND OVER THE PAST 12 MONTHS	99
125% OF PEAK DEMAND	124
RENOVATIONS - ADDED LOAD -	
NEWLY ADDED ESTIMATED DEMAND	172
ESTIMATED TOTAL BUILDING DEMAND LOAD =	296 821A @ 208V

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PROJECT ADDRESS:
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Westminster, CA 92683

100% DESIGN DEVELOPEMENT

DSA APPL NO.: 04-121616 DSA FILE NO.: 30-43

K AD MP
F4F3F2F1 F8F7F6F5 A-B C-D E5E4 F1 F2 E3 SDC

KEY PLAN NORTH: PLAN TRUE

Consultant
REGISTERED PROFESSIONAL ENGINEER STEVEN C. MOSS JR. No. E-19817 Exp. 3-31-2027 ELECTRICAL STATE OF CALIFORNIA

Architect
LICENSED ARCHITECT Hong You No. C-31162 RENEW 10-31-2027 STATE OF CALIFORNIA

CLIENT
WESTMINSTER SCHOOL DISTRICT
DATE 09-30-2025
PROJECT NUMBER 250377

REVISIONS

No.	Description	Date
1	ADDENDUM 1	04/27/2026

100% DESIGN DEVELOPEMENT

SINGLE LINE DIAGRAM & SCHEDULES

E5.01

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