

# PROJECT MANUAL



## COLUMBUS COUNTY SCHOOLS PK-8

GREEN SWAMP ROAD HWY 211 AND SAM POTTS HWY 214  
BOLTON, NORTH CAROLINA 28423

### ISSUE FOR PERMIT / BID DOCUMENT SET

SEPTEMBER 24, 2025

VOLUME NO. 2 OF 2

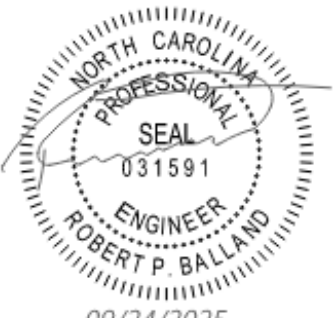


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## DOCUMENT 000107 – PROJECT DIRECTORY AND SEALS PAGES

|                                                                                                                                         |                                                         |                                                                                                     |
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## SECTION 210030 - FIRE PUMP SYSTEM AND ACCESSORIES

## PART 1 - GENERAL

## 1.1 SUMMARY

## A. Section Includes:

1. This section includes the provision, delivery, installation, and startup of one (1) factory built packaged fire pumping system complete with enclosure for installation at the Columbus County Schools PK-8 School located in Columbus County, NC.

## B. Related Requirements:

1. Section 222200 "Plumbing Piping."
2. Section 223000 "plumbing Equipment."
3. Section 260010 "General Requirements for Electrical Systems."
4. Section 260500 "Common Work Results for Electrical Systems."

## 1.2 REFERENCE STANDARDS

- A. NFPA 20, 2013 Edition, Installation of Stationary Pumps for Fire Protection.
- B. NEC 70, National Electrical Code.
- C. ASME, American Society of Mechanical Engineers.
- D. ASTM, American Society for Testing and Material.
- E. ETL, Third Party Certifying Agency.
- F. AWS, American Welding Society.

## 1.3 QUALITY ASSURANCE

- A. Comply with NFPA 20 2020 edition and local and state codes of Columbus County, North Carolina.
- B. System shall be fabricated and assembled in an ISO 9001-2015 certified facility.
- C. System shall bear the ETL label for packaged fire pump systems based on NFPA 20 2020 edition.
- D. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified or denoted on the drawings.
- E. The skid-mounted fire pump shall be assembled by the pump manufacturer. A packager of fire pump skids that is not engaged in the design and manufacturing of NFPA Listed fire pumps shall

not be considered as a fire pump manufacturer. The manufacturer of the packaged fire pumping system shall assume "Single Source Responsibility" for the complete fire pump system.

- F. Test pumps, drivers and controllers at the factory to ensure their performance as specified and as required by NFPA 20 2020 edition. Copies of the certified factory test data shall be available for comparison during field acceptance tests.
- G. The manufacturer shall carry a minimum product liability insurance of \$2,000,000 per occurrence with an aggregate product liability of \$6,000,000.
- H. Test all electrical components for proper installation, connection, and operability.
- I. Furnish all material that is new and unused and free from defects, cracks, and imperfections.
- J. Manufacturer's Qualifications:
  - 1. The Fire Pump Manufacturer and the Packaged Fire Pump System Manufacturer / Assembler shall be the same.
  - 2. The Packaged Fire Pump System Manufacturer shall have a minimum of 30 years of experience in the production and assembly of fire pumps and packaged fire pump systems.
- K. Provide the services of a qualified manufacturer's representative to assist in the installation supervision, complete checkout, startup, and commissioning of the packaged fire pumping system.
- L. The Manufacturer and their Local Distributor shall have the capability to provide repair, maintenance, and parts supply service for all furnished components.
- M. Do not commence fabrication and assembly of the packaged fire pump system until review of all submittal data by Owners Representatives is completed and approval and written release to production is received.
- N. Architect, Engineer, and/or Owners Representative shall be able to inspect the construction of the packaged fire pump system at the manufacturer's facility with 72-hour notice.

#### 1.4 PACKAGED FIRE PUMPING SYSTEM MANUFACTURER PRE-QUALIFICATION TO BID

- A. Packaged Fire Pumping System Manufacturers interested in providing a bid for this project shall furnish a pre-qualification submittal a minimum of fifteen (15) days prior to the bid opening date. The pre-qualification submittal must be prepared specifically for this project. Manufacturer standard technical data sheets or copies of submittals from similar projects are not acceptable and will not be reviewed. The pre-qualification submittal shall include a title page that includes the project name, project number, owner's name, engineer's name, submitting party's name and contact information, date of submittal, and the bid date. The pre-qualification submittal shall include the following:
  - 1. A complete written specification for the proposed packaged fire pumping system, including operating sequence, alarm sequence, and a detailed bill of materials.
  - 2. A written statement from the manufacturer certifying full conformance to this specification and the system layout and dimensions as shown on the plan drawings, including the



- provision of the specified materials and equipment and accessory brands listed or pre-qualified and approved by the Engineer. The statement shall be signed by an officer of the manufacturing firm, and the document shall be notarized.
3. 3-D Isometric model showing overall footprint with all piping elevations and locations. Drawing must be accompanied by a BIM compliant STP file for integration to the site plans.
  4. Complete submittal data for all major equipment, as listed in this specification, including properly indicated pump curves.
  5. A project specific electrical schematic showing power and control wiring for the complete system including the enclosure.
  6. Installation list of 30 similar packaged fire pumping systems which have been in operation for a minimum of 5 years. The list shall include a contact name and phone number for each installation that the Engineer may contact to ask about their experience working with the manufacturer and the equipment provided.
  7. Location and contact information of the closest factory owned and/or factory trained service centers and the date of the last factory training session performed with the service center.
  8. To ensure that the manufacturer submitting for pre-qualification has acceptable quality assurance programs in place, the manufacturer shall submit copies of their ISO9001:2015 Certificate of Registration, their UL Authorization QCZJ.E189340 Packaged Pumping Systems, their UL Authorization NITW.E59076 Industrial Control Panels, and their ETL Authorization under sections 219, 225, and 281 as a part of the pre-qualification submittal. ISO9001:2015 certifications, Quality Management Certificates, UL Authorizations and ETL Authorizations that list the names of parent companies or subsidiary companies are not acceptable.
  9. A copy of the manufacturer's current certificate of insurance showing a minimum product liability insurance of \$2,000,000 per occurrence with an aggregate product liability of \$6,000,000.
  10. To ensure that all welding will be accomplished according to ASME standards, copies of all fabricating employees' ASME Section IX pressure vessel certification and AWS D1.1 structural certification shall be included in the pre-qualification submittal.
  11. A listing of the manufacturer's or authorized service provider's employees authorized for system commissioning and start up, including each employee's name, employee number, years of experience in starting, commissioning, and testing packaged fire pump systems, contact information, and the employee's supervisor's name and contact information.
  12. Pre-qualification submittals that are received by the deadline of a minimum of fifteen (15) days prior to the bid opening date will be reviewed by the Engineer. Manufacturers whose pre-qualification submittal that in the sole opinion of the engineer, meet all of the specified performance and quality requirements for the packaged fire pumping system as set forth in the project documents shall be named by Addendum no less than three (3) days prior to the bid opening date.
  13. All bids shall be submitted using only the Packaged Fire Pumping System Manufacturers that are pre-qualified for use on this project and have been named by Addendum.
  14. Engineer approval of a Manufacturers pre-qualification submittal does not relieve the manufacturer or supplier from providing full and complete submittals if their system is selected for use on the project, nor does it relieve them of having to conform to these specifications and the plan drawings in all respects.
  15. Any bids received that include equipment from a Packaged Fire Pumping System Manufacturer that was not pre-qualified for use on this project and named by Addendum shall be considered as non-responsive and rejected.

16. Manufacturer requests for the substitution of major equipment brand, size, type, or function shall be made in writing prior to the preparation of the pre-qualification submittal and shall only be included in the pre-qualification submittal if previously approved by the Engineer. Otherwise, major equipment shall be as specified in brand, size, type, and function as described herein and on the plans. In no way shall the substitution of an approved alternate piece of major equipment cause the price of the packaged fire pumping system to increase. Instead, a significant decrease in the price shall be expected and required due to the substitution.

#### 1.5 SUBMITTALS

- A. Submit each item in this article according to the conditions of the contract and specifications sections.
- B. Submit manufacturer's installation instructions under provisions of General Conditions.
- C. Product data shall include certified performance curves and related capacities of selected models, weights, furnished specialties and accessories. Indicate the project specific pump operating conditions on pump performance curves.
- D. All submittal information shall be provided in electronic Adobe PDF format

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect all equipment, connection surfaces, piping, wiring, fluid passages and working parts from damage during shipment, handling, storage, and installation.
- B. The packaged pumping system shall be factory assembled and shipped as a complete unit unless shipment in sections is absolutely required or unless shipping restrictions or equipment limitations dictate that smaller portions must be shipped.
- C. Deliver equipment and accessories to the specified location for unloading.
- D. Store material in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.
- E. Repair or replace all items damaged during shipment, delivery, or installation.

#### 1.7 WARRANTY

- A. Warrant that all supplied components will function as specified and as a complete functional system in accordance with all applicable codes and free from defects in design, assembly, manufacture and workmanship for a minimum of twelve (12) months after startup or eighteen (18) months after shipment whichever occurs first.

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PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. The Factory Built Packaged Fire Pumping System shall be Model 2000HSCD75EC-H-ULFM as manufactured by SyncroFlo, Inc. Represented by Carolina Pumpworks of Port Royal, SC 29935, 843-522-9600, Rober Pruitt as basis of design. The factory built packaged fire pumping system shall include a diesel engine driven fire pump and associated controller, internally mounted diesel fuel tank with fuel delivery system, an electric driven jockey pump and associated controller, interconnecting piping, valves, wiring, and accessories all skid mounted as a complete system and housed inside a skid mounted environmental enclosure. The packaged system shall be certified and labeled for its intended use and built according to these specifications and as shown on the plan drawings.
- B. Acceptable alternate Factory Built Packaged Fire Pumping System Manufacturers:
1. Xylem AC – Todd Weir – 214-629-3580.
  2. SPP Pumps – Chris Dilday – 678-896-9168.

## 2.2 SYSTEM COMPONENTS

- A. Fire Pump:
1. Quantity: One (1).
  2. Type: Diesel Engine Driven.
  3. Design: Pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head.
  4. Maximum shutoff head: The shutoff head shall not exceed 140 percent of rated head.
  5. Operating Conditions:
    - a. Capacity: 2000 GPM.
    - b. Total discharge head: 75 PSI.
    - c. Maximum Shutoff Head: 102 PSIG.
    - d. Maximum Speed: 1760 RPM.
    - e. Fire Pump Controls Voltage: 120/1/60.
  6. Pump Type: Horizontal Split Case.
  7. Pump Materials:
    - a. Casing: Cast Iron.
    - b. Impeller: Bronze.
    - c. Shaft: Steel.
    - d. Stuffing Box Packing: Non-asbestos.
    - e. Seal Tubing: Integral with casting, Brass.
    - f. Connections: Flanged class 250.
  8. Provide fire pump accessories in accordance with NFPA 20 2020 edition including but not limited to:

- 
- a. One (1) automatic air release valve.
  - b. One (1) pump suction gauge, range 30-0-30 with shutoff cock.
  - c. One (1) pump discharge gauge, range 0-300 with shutoff cock.
  - d. Common rigid structural steel baseplate (elevated as required) for each pump and its associated drive.
  - e. Drive shaft with OSHA approved guard.
  - f. One manufacturer nameplate for the fire pump, stating:
    - 1) Pump capacity.
    - 2) Total head.
    - 3) Pump RPM.
    - 4) Manufacturer's model and serial number.
    - 5) Casing working pressure.
9. Acceptable Fire Pump Manufacturers
- a. SyncroFlo.
  - b. SPP.
  - c. Xylem A.C.
  - d. Engineer Pre-Qualified and Approved Equal.
10. Pump Design and Construction: Pump shall be UL Listed and FM Approved.
- B. Diesel Engine Drive:
1. Quantity: One (1) 144-Horsepower, T3, 1760-RPM, JU4H-UFADW8, HE Cooled Diesel Engine.
  2. Type: direct drive, designed for operation on diesel fuel for fire pump service, in accordance with NFPA 20 2020 edition.
  3. Horsepower Rating: Not less than 110 percent of maximum brake horsepower (after derating for altitude in accordance with NFPA 20 2007 edition) required to drive the pump at rated speed.
  4. Engine Manufacturer:
    - a. Clarke Fire Power.
    - b. Cummins.
    - c. Caterpillar.
    - d. Engineer Pre-Qualified and Approved Equal.
  5. Provide accessories for each drive including but not limited to the following:
    - a. Adjustable governor capable of regulating speed within a range of 10 percent between shutoff and maximum load conditions of pump.
    - b. Overspeed shutdown device
      - 1) Designed to stop engine at 20 percent above rated speed.
      - 2) Position: Supervised so automatic controller will show overspeed trouble signal until shutdown device is manually reset.
      - 3) Manual reset.
    - c. Speed Switch:

- 1) Function: Signal engine running and crank termination.
  - 2) Source of Power: Source other than engine generator or alternator.
- d. Instrument Panel including but not limited to:
- 1) Tachometer.
  - 2) Oil pressure gauge.
  - 3) Water temperature gauge.
  - 4) Hour meter.
  - 5) Ammeter.
- e. Cooling System:
- 1) Type: Closed circuit.
  - 2) Water source: Discharge side of pump.
  - 3) Components:
    - a) Engine drive circulating pump.
    - b) Heat exchanger.
    - c) Engine jacket temperature regulator or thermostat.
    - d) Two manual shut off valves for cooling water supply.
    - e) Strainer for cooling water supply.
    - f) Pressure regulating valve for cooling water supply.
    - g) Pressure gauge for engine side of cooling water supply before last manual valve.
    - h) Valved bypass around circuit from inlet side of first valve to outlet side of second manual valve.
    - i) Visible open waste cone.
    - j) Heat exchanger discharge shall be piped to the floor drain.
- f. Water cooled jacketed exhaust manifold.
- g. Jacket water heater, 120 VAC, single phase, 60 hertz.
- h. Flexible metallic fuel lines, with necessary protection.
- i. In line fuel filter.
- j. Oil pressure safety switch.
- k. Air cleaner.
- l. Engine driven oil pump.
- m. Enclosed control wiring.
- n. Electric starter with voltage regulator.
- o. Two heavy duty 12-volt, lead acid batteries, with corrosion resistant battery rack and cables as required; charged from engine generator or alternator and automatic trickle charger.
- p. Residential grade engine exhaust silencer with spark arrestor, flexible exhaust connection, ventilated thimble (as required), and suitable factory painted or galvanized supports for supporting silencer. A flexible connector with flange connections shall be provided at the engine. Flexible sections shall be stainless steel and suitable for diesel-engine exhaust gas at 1000 deg F minimum.
- q. Horizontal factory painted double wall carbon steel UL labeled fuel storage tank, with legs, level gauge, low level fuel switch, vent with flame arrestor, and necessary connections for fill, outlet, and fuel return. The fuel tank shall have a capacity at least equal to 1 gal per horsepower (5.07 L per KW) "Minimum", plus 5 percent

volume for expansion and 5 percent volume for sump per NFPA 20 2007 edition 11.4.3.1. The tank shall be equipped with a leak sensing float switch wired to the diesel controller. Float switch shall be Flotronix Model No. FLO-L10785-SS.

- r. Fuel tank piping shall be flexible hose in double containment protective piping with lockable ball valve in supply line, there shall be no shutoff valve in the return fuel piping.

C. Diesel Fire Pump Controller:

- 1. The Fire Pump Controller shall meet the requirements of NFPA 20 2020 edition.
- 2. The controller shall have twin battery chargers meeting NFPA 20 2020 edition requirements. The battery chargers shall have reverse polarity protection/indication and be capable of recharging a completely discharged battery within 24 hours. The chargers shall auto detect the input voltage of either 120 VAC or 220 VAC and shall be able to be programmed for either 120 VDC or 24 VDC output.
- 3. A solid-state pressure transducer shall be installed in a bulkhead in the enclosure bottom so that all plumbing connections are made external to the controller. The controller piping and pressure system shall be rated for pressures up to 600 PSIG within +/- 1.5% accuracy.

D. Jockey (Pressure maintenance) Pump:

- 1. Quantity: One (1) 3-Horsepower, 3500-RPM, 460-Volt, 3-Phase, 60-Hz Jockey Pump with Premium Efficiency TEFC Motor.
- 2. Configuration: Vertical Multistage.
- 3. Materials:
  - a. Casing: Cast iron and stainless steel.
  - b. Shaft: Steel.
  - c. Trim and impeller: Bronze or stainless steel.
- 4. Operating Conditions:
  - a. Capacity: 20 GPM.
  - b. Total head 85 PSIG.
  - c. Maximum Shutoff Head: 188 PSIG.
  - d. Speed: 3500 RPM Maximum.
  - e. Voltage: 460/3/60.
- 5. Provide accessories including but not necessarily limited to:
  - a. Common structural steel baseplate for pump and drive elevated as required.
  - b. Motor: TEFC.
- 6. Manufacturer's nameplate stating:
  - a. Pump capacity.
  - b. Total head.
  - c. Manufacture's model number and serial number.
- 7. Acceptable manufactures:

- a. Ebara.
- b. Webtrol.
- c. Xylem/Goulds.
- d. Engineer Pre-Qualified and Approved Equal.

E. Jockey Pump Controller:

1. Function: Cycling jockey pump to maintain system pressure of 85 psig; pump shall start at 80 and shut off at 90.
2. Jockey pump controller shall be UL Listed and FM Approved.
3. The jockey pump controller shall have as a minimum but not limited to the following alarms:
  - a. Power Failure.
  - b. Phase Reversal.
  - c. Pump Running.

F. The jockey pump shall have as a minimum but not limited to the following standard features:

1. Horsepower rated disconnect switch, fuse block, and fuses.
2. Horsepower rated motor contactor and overload relay.
3. Minimum run timer to prevent short cycling of pump.
4. HAND-OFF-AUTO selector switches to allow manual operation of the pump.
5. 0-300 psi pressure switch suitable for freshwater applications.

G. Packaged Fire Pumping System Skid Base:

1. All the equipment including but not limited to fire pump, diesel engine driver, jockey pump and motor, valves, instrumentation, and controls shall be mounted on a common steel base of open frame construction to form a complete and operating pumping system. Peripheral structural members shall be from channel or wide flange beam ASTM 36. Internal structural members shall be from channel or rectangular tubing ASTM 36, all welded per the AISC Manual of Steel Construction, part 4, "Welded Joints". Provisions shall be made in the station base for loading and offloading and handling the station at the site. Lift eyes shall be designed to eliminate trip hazard once the station has been set in place.
2. The installing contractor shall set the packaged fire pump system on a contractor supplied concrete slab that extends a minimum of 12-inches beyond the packaged fire pump skid on all four sides. All piping penetrations shall enter and exit the packaged fire pump system through the exterior walls of the packaged fire pumping system enclosure. Once the packaged fire pump system is leveled and all piping and electrical connections are made, the installing contractor shall pour a concrete floor inside the building. The Packaged Fire Pumping System manufacturer shall include two (2) NPT threaded drain piping connections through the structural steel perimeter beams of the skid. The installing contractor shall be responsible for installing a minimum of two (2) floor drains in the concrete floor and piping them through the perimeter I-Beam structure to daylight. The concrete floor shall be sloped as required to facilitate proper drainage to the contractor provided and installed floor drains. Once the concrete floor has cured, the installing contractor shall fill the fire pump base and the diesel engine base with non-shrink grout. The perimeter structural support I-Beams shall be taller than the interior structural support members and all equipment mounting elevations shall be placed appropriately so as not to

interfere with the installation of the concrete floor and the equipment base grout installation.

H. Piping

- I. All piping shall be constructed from ASTM A53, grade B, type E standard weight pipe. The package piping shall consist of grooved fittings and couplings in and out of the pumps. All piping shall be sized per NFPA 20 2020 edition, table 4.26(a). Qualification of the welding procedures and performance of the welders shall comply with the requirements of ASME code, Section IX. All piping valves and fittings shall be in accordance with NFPA 20 2020 edition. Piping supports shall be provided for all suction and discharge piping. All pipe supports shall be designed to allow for the removal of any individual sections without adding additional stress to adjoining sections or pumps.

J. Fire Pump Fittings

1. Fire pump fittings shall include at a minimum the following: an automatic air release valve, discharge pressure gauge (3.5-inch dial) supplied and sized per NFPA 20.
2. All piping shall be sized per NFPA 20 2020 edition Table 4.26(a).
3. Valves shall be UL and ULC listed and FM approved, with 250-psig minimum pressure rating.
4. Where the suction pipe and pump suction flange are not of the same size they shall be connected by an eccentric tapered reducer or increaser installed in such a way as to prevent air pockets.
5. A listed grooved style check valve shall be installed in the discharge piping. Valve shall comply with UL 312 unless noted.
6. A listed indicating butterfly valve shall be installed on the fire protection side of the pump discharge check valve.
7. All drains shall be piped to a common point for connection to an installer provided and field installed floor drain per NFPA 20 2007 edition.

K. Fire Pump System Accessories

1. Hose Valve Test Header Piping Assembly: System shall be equipped with a hose valve header and valves. The hose valve header shall be sized per NFPA 20 2020 edition Table 4.26(a). Hose valve header shall be manufactured from cast iron or fabricated from ASTM A53 standard weight pipe. The test header shall be equipped with listed valves and the number and size of hose valves for testing shall be as specified in Table 4.26(a). Hose valves shall be listed, 2-1/2" National Standard Thread, equipped with caps and chains unless otherwise specified. The hose valve header shall be equipped with a listed butterfly isolation valve that will remain closed during normal and standby operation modes. Hose header shall be fitted with a ball drip valve to prevent freezing after testing and a minimum 3/4-inch drain piped to a common discharge point.
2. Main Relief Valve Piping Assembly: Where a total of 121 percent of net rated shutoff (churn) pressure plus the maximum static suction pressure, adjusted for elevation, exceeds the pressure for which the system components are rated a pressure relief valve shall be installed. The pressure relief valve shall be located between the pump and the pump discharge check valve and be installed so it can be readily removed for repairs without disturbing the piping. The pressure relief valve shall be a spring loaded or pilot-operated diaphragm type valve. The relief valve shall discharge into an open pipe or into a cone or funnel secured to the outlet of the valve. If a closed type cone is used, it shall be provided



- with a means for detecting motion of water through the cone. The pressure relief valve shall be UL Listed and FM Approved.
3. Flow Meter Loop Piping Assembly: System shall be equipped with a flow meter loop sized in accordance with NFPA 20 2020 edition Table 4.26(a). The metering device shall be of the venturi type with grooved connections and installed per the manufacturer's directions. The flow meter loop shall be complete with flow meter, and isolation butterfly valves that will remain closed during normal and standby operation modes.
  4. The flow meter piping shall be piped to the skid edge for return to the adjacent ground level water storage tank. The installing contractor shall ensure coordination with the tank supplier to make sure the tank includes the necessary flanged piping connections for the water supply piping to the Packaged Fire Pump System and for the Flow Meter Loop return piping back into the tank. This coordination shall occur during the submittal preparation stage so that the Packaged Fire Pump System piping connections and the Tank piping connections can be properly reviewed and approved by the Engineer.

L. Painting:

1. The Packaged Fire Pumping System Manufacturers standard Factory Coating System shall be provided in compliance with ISO 12944 Category C2, SyncroFlo coating specification SPCP-0014. (Applications: heated or unheated buildings with clean atmospheres and where some condensate may occur).

## 2.3 PACKAGED PUMPING SYSTEM ENCLOSURE

A. System Enclosure:

1. The entire packaged fire pumping system shall be installed inside an environmental enclosure to protect it from the elements. The enclosure shall be complete as specified herein including shop wiring, piping, and testing of the equipment furnished under these equipment specifications. The enclosure shall be mounted on the Packaged Fire Pumping System's structural steel skid base at the manufacturer's facility prior to shipment.
2. The environmental enclosure shall be manufactured by Kysor Panel Systems, Fort Worth, TX or Engineer Pre-Qualified and Approved Equivalent. Refer to specification section 1.3 for Pe-Qualification requirements.
3. The enclosure shall be the manufacturer's standard design that meets or exceeds the site design conditions. The enclosure shall have an open floor with perimeter frame and structural members with provisions for bolting to the structural steel packaged fire pumping system skid. A means for lifting the assembled enclosure without damage to the enclosure using overhead rigging shall be provided.
4. Arrangement: The Packaged Fire Pumping System Manufacturer shall arrange the equipment furnished under these equipment specifications to allow proper access to the components for operation and maintenance. The minimum headroom in all walkways shall be 7 feet. The enclosure shall be completely assembled and installed on the Packaged Fire Pumping System skid at the manufacturer's assembly plant, with all the accessories listed in this specification fully installed, wired, and tested prior to shipment to the job site, including the fire pump equipment, disconnect switches, panel board(s) and transformer(s), lighting, light switches and receptacles required to make a complete and operating system.

B. Design Criteria:

1. All enclosures shall be designed in accordance with the applicable sections of the latest edition of the International Building Code and conform to ASCE (American Society of Civil Engineers) "Minimum Design Loads for Buildings and other Structures."
2. Each enclosure shall be designed for the following loads, in addition to the stationary weight of the enclosure. Reduction of loads due to tributary loaded areas will not be permitted.
3. The vertical live load of the enclosure shall not be less than 40 pounds per square foot applied on the roof.
4. The horizontal wind load of the enclosure shall not be less than 110 MPH and shall be distributed and applied in accordance with the applicable edition of the International Building Code and ASCE.
5. The enclosure shall be designed to resist the effects of seismic ground motions in accordance with IBC standards.
6. All combining and distributing of auxiliary equipment loads imposed on the enclosure system shall be done in accordance with the applicable section of the ASCE.
7. Upon request, the selected enclosure manufacturer shall provide the enclosure purchaser with a complete design certification signed and sealed by a registered professional engineer. If requested, this documentation is typically provided after the manufacturing of the enclosure is complete and will be provided as part of the IOM Manual.

C. Modular Panel Construction:

1. All enclosures shall be constructed with prefabricated wall and ceiling panels formed to exact size. All panels to be constructed with die-formed interior and exterior metal pans securely fastened to a perimeter frame of kiln dried spruce-pine-fir (SPF) specie, #2 grade lumber. Perimeter frame to feature tongue and groove profile for positive alignment and sealing and shall utilize pressure treated lumber. Panels shall be filled with poured-in-place urethane, which securely bonds to metal pans and perimeter frame creating a rigid structural panel with a tough, resilient, shock-resisting surface. Standard panels shall be interchangeable for ease of assembly. Special panels (if required) shall be manufactured to the size required to obtain the specified building size.

D. Panel Fasteners:

1. Cam-lock fasteners provide a tight and positive seal. These fasteners reduce installation time to a minimum. Fastener material shall be steel housing, hook, and pin with high-pressure die-cast zinc cam. A hardened steel hexagonal wrench is provided to tighten panel fasteners. The hook of the fastener shall engage over the pin when rotating the wrench and with cam-action, draw the panels tightly together. Polyethylene snap-in caps cover the wrench holes. Lock spacing shall not exceed 48" on center.

E. Panel Gaskets:

1. Each joint shall exhibit a polyvinyl chloride (PVC) bulb type; compression gasket to eliminate water vapor permeability. All gaskets are factory installed and require no additional handling. Gaskets shall be resistant to chemical corrosion and ultraviolet radiation. Gasket operating temperature shall be -34 degrees C to +71 degrees C (-30 degrees F to +160 degrees F).

F. Insulation:

1. Insulation shall be 100 percent rigid urethane with a conductivity factor (K factor) not to exceed 0.128 Btu/hr. Urethane is to be poured in place with a density of 2.2 pounds per cubic foot. Overall coefficient of heat transfer (U factor) and R value to be as follows:

|             | THICKNESS    | U-FACTOR | R-VALUE |
|-------------|--------------|----------|---------|
| Wall Panels | 3-1/2 inches | 0.036    | 28      |
| Roof Panels | 5 inches     | 0.025    | 40      |

2. This insulation shall be a listed urethane with a rating of no more than 25 for flame spread and 450 for smoke developed per ASTM E84. This urethane will also meet the ignition properties requirements of ASTM D1929.

G. Panel Finishes

1. Interior and Exterior metal pans shall be nominal 24-gauge galvanized steel conforming to ASTM A653 specifications with the galvanized coating conforming to G60 standards. Minimum yield strength of the panel material shall be 50,000 PSI. The interior finish shall be white embossed and the exterior finish shall be San Tan or Polar White embossed with mesa profile. Panel finish shall be factory applied coating of 0.9 to 1.1 mils of dry film thickness. Standard colors are "Polar White & San Tan."
  - a. The finish coat shall be a baked-on siliconized polyester formulation that will meet the following performance standards after 10 years continuous exposure in "normal" atmospheric conditions not containing corrosive fumes such as chemicals or salt spray.
    - 1) Panel finish shall show no evidence of blistering, peeling, or chipping.
    - 2) Panel finish shall not show surface chalking in excess of the No. 4 rating D659 as established by the American Society of Testing Materials (ASTM).
    - 3) Panel finish after cleaning, shall not show color change in excess of 7 NBS units when measured in accordance with the ASTM D-2244 standard.
    - 4) The above performance standards shall not apply where panels have been damaged by fire, radiation or other physical damage.

H. Roof System:

1. A prefabricated roof system shall be provided for the enclosure to provide a waterproof covering for insulated ceiling panels.
2. The roof system shall be a galvanized standing seam, 22 gauge, 16 inches wide, sheet metal over ceiling panels with a slope of 1/4 -inch per foot. Fasteners shall be corrosion resistant rubber washered TEK screws with length and strength required for the metal to be securely fastened.

I. Wall Panel Design:

1. Exterior wall panels of the enclosure shall be a single continuous length from the steel skid to the roof panel of the enclosure and at the side walls and the end walls of the enclosure except where interrupted by wall openings.

2. Wall panels shall be fastened from the interior through a steel plate in the skid with 3/8" diameter electro-galvanized lag bolts. The fastening system shall be designed so that no wall fasteners are exposed on the exterior surface of the walls.

J. Enclosure Roof Assembly:

1. Each enclosure roof shall have 1/4-inch pitch in enclosure width. Roof panels shall have interlocking tongue and groove connections and shall be attached to the wall through factory pre-drilled holes with 3/8-inch corrosion resistant fasteners and an interior angle fastened to the walls and top panels. The roof system shall include a factory manufactured "J" rail at the low side wall. The "J" rail shall be nominal 18-gauge galvanized steel.
2. Transmission of horizontal wind loads across the enclosure shall be made through the panel roof system and no separate roof or wall diagonal bracing shall be required.
3. Structural frame wind belts and wind bents shall not be required for proper transmission of lateral winds loads.

K. Hollow Metal Doors

1. All doors shall be 1-3/4-inch-thick flush-type. Door panels shall be nominal 18 gauge cold rolled steel reinforced by lamination to a polystyrene core enclosed with 16-gauge end channel. The hinge reinforcements shall be nominal 7-gauge, and the lock reinforcements shall be nominal 16-gauge.
2. Door frames shall be 4-3/4-inch deep double rabbited type of nominal 16-gauge cold rolled steel.
3. Door and frames shall be factory painted with one coat of baked on primer and one coat of baked on epoxy finish paint coating. All doors shall be pre-assembled in their frames and hardware installed and tested prior to shipment.

L. Door Hardware:

1. Door hardware shall consist of:
  - a. Three (3) 4-1/2 by 4-1/2 inch standard weight, plain bearing hinges per ANSI A5133 630 stainless steel finish with non-rising pins.
  - b. 3-1/2 inch wide by 1-inch-high extruded aluminum threshold (Out Swing).
  - c. 3/16 by 5/16 inch silicone rubber weather-stripping.
  - d. Cal-Royal deadbolt lockset per ANSI Grade 3, LSD-01 Series, stainless steel finish.
  - e. Cal-Royal BA-30 Keyless Passage set, Grade 2, ANSI F75-2, stainless steel finish.
  - f. Door closer is certified to conform to ANSI 156.4 Grade 1 and meets exterior barrier free codes in 689 aluminum powder coat finish.

M. Enclosure Accessories:

1. Electrical
  - a. All above grade wiring shall be installed in surface mounted EMT conduit installed per NFPA 20 2020 edition and the latest edition of NEC. All conduit installed below grade shall be hot dipped rigid conduit. Flexible liquid-tite conduit 18" maximum length shall be permitted at equipment and enclosure connections.
  - b. System to be equipped with a single point power connection with terminal strip for distribution to all electrical equipment. Enclosure shall be Nema 12 rated

- c. Power Supply: The pump station manufacturer shall provide an auxiliary power transformer if required. The transformer shall be mounted and wired on the skid. It shall deliver 240/120-volt single phase power to its distribution panel sized to support all building loads without overloading. The transformer shall be of the dry shielded type enclosed in a NEMA 3R rated enclosure. The transformer shall be UL listed and comply with the latest edition of NEC.
  - d. Lighting: The enclosure shall be equipped with interior, exterior and emergency lighting per NFPA 20 2007 edition and installed per the latest edition of the NEC.
    - 1) Interior lighting: The enclosure shall be equipped with a minimum of two (2) ceiling mounted LED wrap around type fixtures. The lighting levels shall be as recommended by the I.E.S. (Illuminating Engineering Society). The light fixture shall be rated for damp and dusty applications. The fixture shall be UL Listed.
    - 2) Exterior lighting: The enclosure shall be equipped with a minimum of one (1) exterior lighting fixture per door. The fixture shall be of the LED type with photoelectric automatic dusk to dawn control. The fixture shall be UL Listed.
    - 3) Emergency Lighting: The enclosure shall be equipped with emergency lighting. The fixture shall provide a minimum of 90 minutes of illumination and be powered by a maintenance free lead-calcium battery.
  - e. Receptacles: The manufacturer shall furnish and install 120-volt wall mounted convenience outlets. The outlets shall be located in an accessible area of the enclosure. The outlets shall be of the GFCI (ground fault circuit interrupting) type. The outlets shall be UL Listed.
- N. Heating and Ventilating:
- 1. Sizing of the fans, louvers and heaters shall be supported by calculations per NFPA 20 2020 edition.
  - 2. The enclosure shall be equipped with a thermostatically controlled electric space heater capable of maintaining a minimum of 40 deg F per NFPA 20 2020 edition. The heater shall be wall or ceiling mounted, and fan forced with adjustable outlet louvers.
  - 3. Ventilation shall be provided for the following functions:
    - a. To control the maximum temperature to 120 deg F (49C) at the combustion air cleaner inlet with the engine running at rated load.
    - b. To supply air for engine combustion.
    - c. To remove any hazardous vapors.
    - d. To supply and exhaust air as necessary for radiator cooling of the engine when required.
- O. Exhaust Fan: The enclosure shall be equipped with a high capacity, direct drive propeller wall mounted fan. The fan shall come complete with wall collar, rear guard and exhaust damper. The fan shall be controlled by a wall mounted thermostat. The fan shall meet NFPA 20 2007 edition and be UL listed and OSHA compliant.
- P. Inlet louver: The enclosure shall be equipped with electric actuated, center pivot damper with bug screen mounted on the enclosure exterior. The louver shall be 120/1/60V powered closed, spring open and fail in the open position, fast acting, two position and shall be UL Listed and OSHA

compliant. The louver shall be interlocked with the diesel engine controller to open upon engine starting.

Q. Testing:

1. The fire pump will be factory performance tested in accordance with the requirements of NFPA, UL and FM. The fire pump and jockey pump controllers will be electrically tested prior to shipment. Additionally, the entire package system will be hydrostatically tested at the factory at a pressure rating per NFPA 20 Section 11-1.1 for a minimum of 2 hours. A copy of the test procedures shall be provided upon request.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Place, assemble, install and place into operational readiness the complete packaged fire pumping system and system enclosure as specified in this section, in accordance with Syncroflo recommendations, Drawings, FM and NFPA 20 2007 edition.

#### 3.2 FIELD QUALITY CONTROL

- A. Manufacturers field representative shall supervise the installation of all items and equipment as specified in this section as needed.
- B. The Contractor shall inspect the jobsite conditions 72 hours before shipment of the packaged fire pumping system to ensure the site is ready and the site conditions are compatible with the specified system layout.
- C. Manufacturers field representative shall conduct and document field acceptance tests and startup of the equipment specified in this section and shall ensure conformance to acceptance requirements of NFPA 20 2020 edition and FM Data Sheet 3-7N/13-4N.
- D. Manufacturer's representative shall instruct Owner's personnel in the proper system operation and maintenance.
- E. Manufacturer's representative shall commission equipment and certify to Owner in writing that all installation, maintenance instruction, tests, adjustments, repairs and startup are complete and that all components are ready for continuous operation.

#### 3.3 START UP AND COMMISSIONING

- A. The system manufacturer or his representative shall provide commissioning of the complete packaged fire pumping system. The commissioning shall include verification of the proper installation by the installing contractor, system check out, adjustment and complete start-up. The commissioning will occur only when all hook-ups, tie-ins and terminations have been completed and signed off on the manufacturer's start-up request form by the installer.

- B. The commissioning will require the system manufacturer or his representative to provide on-site training for the Owners personnel on the operation and maintenance of the packaged pumping system.

#### 3.4 TRAINING

- A. After the equipment start-up and field testing is complete, the system manufacturer or his representative shall provide instructional training.
- B. Provide training, operation, and maintenance and trouble-shooting instruction to the owner's operations and maintenance staff.
- C. Provide instruction for a minimum of one (1) hour.
- D. Provide minimum 14-day notice prior to start-up and training.
- E. Start-Up and Owner Training shall occur on the same day. The installing Contractor shall be responsible for coordinating the Start-Up and Owner Training to ensure the Owners staff are on site for the entire duration of the equipment Start-Up and Owner Training session.

END OF SECTION 210030

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## SECTION 210500 – COMMON WORK RESULTS FOR FIRE SUPPRESSION

### PART 1 – GENERAL:

- 1.1 The General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.
- 1.2 All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals for any part of the work, services, materials or equipment to be used on or applied to this project are hereby directed to familiarize themselves with the Contract Documents. In case of conflict between these General Provisions and the General and/or Special Conditions, the Contractor shall contact the Engineer for clarification and final determination prior to the Bid.
- 1.3 The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Fire Suppression Systems indicated or specified in the Contract Documents.
- 1.4 Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete any part of the Fire Suppression Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.
- 1.5 It is not the intent of this Section of the Specifications to make any Contractor, other than the General Contractor, responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the General Contractor to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.
- 1.6 The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer's convenience and is not intended to define a subcontractor's scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Contract Documents when preparing Bids, prices and quotations. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.
- 1.7 It is the intent of the Contract Documents to deliver to the Owner a new, complete and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.
- 1.8 In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least seven (7) days prior to the interruption of any

services (gas, domestic water, heating, etc.). The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.

- 1.9 Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Contractor's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation from the Owner.
- 1.10 Each Contractor shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.
- 1.11 DEFINITIONS AND ABBREVIATIONS:
- Contract with Contractor - Any Contractor whether bidding, proposing or working independently or under General Contractor, or Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the General Contractor.
  - Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
  - Architect - The Architect of Record for the project.
  - Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, General and Special Conditions, Addenda, Alternates, Unit Prices, Shop Drawings, Field Orders, Change Orders, Construction Contract with Owner, and other documents enumerated in the Owner/Contractor Agreement.
  - Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.
  - The Project - All of the work required under this Contract.
  - Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
  - Provide - Furnish and install complete, tested and ready for operation.
  - Install - Receive and place in satisfactory operation.
  - Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto or incorporated in the contract documents by reference.
  - Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
  - ADA - Americans with Disabilities Act.
  - ANSI - American National Standards Institute.
  - ASME - American Society of Mechanical Engineers.
  - IBC - International Building Code.
  - NEC - National Electrical Code.
  - NEMA - National Electrical Manufacturers Association.
  - NFPA - National Fire Protection Association.
  - OSHA - Office of Safety and Health Administration.
  - UL - Underwriters Laboratories.

## PART 2 – INTENT AND INTERPRETATION:

- 2.1 It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included in the contract sum.
- 2.2 All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
- 2.3 Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
- 2.4 The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.
- 2.5 The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten (10) days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

## PART 3 – INDEMNIFICATION:

- 3.1 Refer to Project General Conditions and Supplementary Conditions.
- 3.2 The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

## PART 4 – PLANS AND SPECIFICATIONS:

- 4.1 The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with

the work. The Plans are not intended to show every item which may be necessary to complete the systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.

- 4.2 The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.
- 4.3 The Plans and Specifications shall be considered to be complimentary and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
- 4.4 Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.
- 4.5 The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.
- 4.6 Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.
- 4.7 Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to ensure no conflict with other work.
- 4.8 Each Bidder/Proposer shall review all Plans in the Contract Documents to ensure that the work they intend to provide does not create a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular ensure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to ensure adequate spaces.
- 4.9 Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

- 4.10 Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
- 4.11 Where within the Contract Documents the word “typical” or “typ.” is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.
- 4.12 Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.
- 4.13 The Contractor shall provide a layout confirmation of equipment rooms to verify that all of the equipment submitted and approved will in fact fit into the proposed space and have adequate clearance for service. See COORDINATION DRAWINGS SECTION.

#### PART 5 – EXAMINATION OF SITE AND CONDITIONS:

- 5.1 Each Bidder/Proposer shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.
- 5.2 Each Bidder/Proposer shall also fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

#### PART 6 – EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

- 6.1 When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, that the design allows for it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.
- 6.2 Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting

competition; unless specifically indicated; any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part are met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of cities, towns, states or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

- 6.3 Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.
- 6.4 Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.
- 6.5 Coordinate kitchen equipment selection by the General Contractor prior to Bid. Any deviations and/or conflicts for any kitchen equipment shall be the Contractor's responsibility.

#### PART 7 – CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:

- 7.1 The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, inspections and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.
- 7.2 Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.
- 7.3 The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus and Plans in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.
- 7.4 All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.
- 7.5 All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of, or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.
- 7.6 All plumbing work is to be constructed and installed in accordance with applicable codes, Plans and Specifications which have been approved in their entirety and/or reflect any changes

requested by the Authority Having Jurisdiction. Plumbing work shall not commence until such Plans are in the possession of the Plumbing Contractor.

- 7.7 The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.
- 7.8 Where minimum code requirements are exceeded in the Design, the Design shall govern.
- 7.9 The Contractor shall ensure that their work is accomplished in accord with the OSHA Standards and that they conduct their work and the work of their personnel in accord with same.
- 7.10 All work relating to the handicapped shall be in accord with regulations currently enforced by the Authority Having Jurisdiction and the American Disabilities Act.
- 7.11 Work in elevators, elevator shafts and elevator equipment rooms shall comply with the Elevator Code enforced by the Authority Having Jurisdiction.
- 7.12 All work in relation to domestic water systems shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the requirements of the local water utility company.
- 7.13 Discharge of any toxic, odorous or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.
- 7.14 Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense.

#### PART 8 – QUALIFICATIONS OF CONTRACTOR/WORKERS:

- 8.1 All Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.
- 8.2 All fire suppression subcontractors bidding the fire suppression scope of work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.
- 8.3 All fire suppression work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workers and unqualified or incompetent workers shall refrain from work in areas not deemed satisfactory. Requests for relief of workers shall be made through the normal channels of Architect, Contractor, etc.

- 8.4 The Contractor shall hold all required licenses in the State which the work is to be performed.
- 8.5 All plumbing work shall be accomplished by licensed contractors with Journeymen or Master Plumbers as defined under State Plumbing Law Regulations and Code.
- 8.6 All special systems (Automatic Sprinkler Equipment, etc.) shall be installed only by workers normally engaged in such services. Exception to this specification may only be made in writing by the Engineer.
- 8.7 All electrical work shall be accomplished by licensed contractors with Journeymen or Master Electrician as defined under State Regulations and Code. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

#### PART 9 – SUPERVISION OF WORK:

- 9.1 The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

#### PART 10 – CONDUCT OF WORKERS:

- 10.1 The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt removal of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or debilitating drugs on the job site is strictly forbidden.

#### PART 11 – COOPERATION AND COORDINATION WITH OTHER TRADES:

- 11.1 The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.
- 11.2 Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than  $\frac{1}{4}" = 1'-0"$ , clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.
- 11.3 The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.



PART 12 – GUARANTEES AND WARRANTIES:

- 12.1 The Contractor shall guarantee all equipment, apparatus, materials, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective within the time frame outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Project's Statement of Substantial Completion. Items of equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.
- 12.2 Provide all warranty certificates to Owner. All warranties begin starting at the substantial completion date, submit warranty certificates accordingly.

PART 13 – COST BREAKDOWNS (SCHEDULE OF VALUES):

- 13.1 Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.
- 13.2 The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc.:
- Shop Drawings
  - Motor Load Coordination with other subcontractors
  - Record Drawings & Acceptance
  - O&M Manuals & Acceptance
  - Owner Training & Acceptance
  - Spare Parts
  - Coordination Drawings
  - Identification Materials & Labor
  - Piping Materials & Labor
  - Piping Testing, Cleaning, Documentation, Acceptance, etc.
  - Piping Purging, Flushing, Cleaning
  - Fire Protection Shop Drawings
  - Fire Protection Materials & Labor
  - Fire Protection Record Drawings & Acceptance
  - Other Equipment & Labor
  - Other Equipment Startup, Testing, Documentation, Training, Acceptance, etc.

PART 14 – CHANGES IN WORK:

14.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

PART 15 – CLAIMS FOR EXTRA COST:

15.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

PART 16 – MATERIALS AND WORKMANSHIP:

- 16.1 All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and/or disassemble/reassemble the materials and equipment and this work shall be the responsibility of the Contractor, whether specifically initiated or not.
- 16.2 All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of fans, motors, coils, filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Ensure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.
- 16.3 Materials and equipment shall bear Underwriters' Laboratories label where such a standard has been established, where applicable.
- 16.4 Each length of pipe, fitting, trap, fixture and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.
- 16.5 All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a name plate indicating required horsepower, voltage, phase and ampacity. Pumps shall have a data plate indicating horsepower, pressure and flow rate.

PART 17 – HAZARDOUS MATERIALS:

- 17.1 The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building or site.
- 17.2 Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall ensure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.
- 17.3 CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or

location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.

- 17.4 If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.
- 17.5 The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.
- 17.6 No asbestos or mercury containing materials shall be installed in this project.
- 17.7 It is the policy of the Owner that no asbestos - containing materials are to be purchased by the Owner, supplied by any person supplying to the Owner or installed in or on Owner property by any person performing work for the Owner. Furthermore, all products marked "May contain Mineral Fiber" will be assumed to contain asbestos unless the manufacturer provides written certification that no asbestos fibers are present in the product and identifies the fibers for which the product is marked. An exception to this rule can be made where a faculty or staff member certifies that the use of asbestos is essential to an ongoing research or production project and works with Environmental Health and Safety Department to ensure that the material is used, stored and disposed of in safe and legal manner.

#### PART 18 – COORDINATION DRAWINGS:

- 18.1 Detailed electronic coordination drawings shall be required for this project. A specific line-item shall be included on the schedule of values by each Trade for "preparation of coordination drawings". This line-item value shall be approved by the Engineer. The Engineer and the Engineer's Field Inspector shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.
- 18.2 Coordination Drawings shall be provided on this project. Drawings shall be prepared in electronic format utilizing AutoCad software. The Architect and Engineer will supply electronic drawings files of the Contract Documents upon the Contractor's request and release.
- 18.3 The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits and other conduits 2" and larger, and piping and components in ceiling spaces. The Coordination Drawings shall be prepared by the Mechanical Contractor. The Coordination Drawings shall indicate (1) systems above ceilings in finished areas, (2) systems supported from the structure in finished areas without ceilings, (3) systems in the mechanical rooms, and (4) all wall, roof, floor penetrations. These drawings shall indicate all ductwork as double lined with bottom elevations noted.
- 18.4 Pre-Coordination Meetings with all necessary trades shall occur. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc will be installed with respect to the sheetmetal fabrication drawings and other trades. The sheetmetal ductwork and gravity piping systems shall be given the first priority. Each Trade shall provide

the Mechanical Contractor electronic drawings of all of their systems (with elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings shall then occur so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at these Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.

- 18.5 It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
- All supply/return/exhaust ductwork.
  - All above slab sanitary and roof drainage piping.
  - HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
  - Electrical conduits which are 1.5" in size and greater.
  - Cable tray and bridal ring paths.
  - Multiple smaller piping/conduits hung on a common trapeze hanger.
  - All wall, roof, floor penetrations.
- 18.6 After completion of the Final Coordination Drawings, a Final Review with the all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meetings will be required to ensure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed to each Trade by the Mechanical Contractor.
- 18.7 Each Contractor shall ensure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on Coordination Drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings.
- 18.8 The fire protection contractor is responsible to the general contractor for the shop drawing layout of the following rooms and details:
- Equipment room layouts with actual equipment
  - Congested areas above ceilings adjacent to mechanical and electrical room

#### PART 19 – TEMPORARY SERVICES:

- 19.1 The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.
- 19.1 All temporary services shall be removed by Contractor prior to completion of work.

#### PART 20 – SURVEY, MEASUREMENTS AND GRADE:

- 20.1 The Contractor shall lay out their work and be responsible for all necessary lines, levels, inverts, elevations and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.
- 20.2 The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

- 20.3 Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

**PART 21 – PROTECTION OF EQUIPMENT:**

- 21.1 The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged, stolen or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense.

**PART 22 – REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:**

- 22.1 The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, equipment, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost. Coordinate with the Electrical Contractor prior to any work.

**PART 23 – EQUIPMENT SUPPORT:**

- 23.1 Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

**PART 24 – PIPE MOUNTING HEIGHTS:**

- 24.1 All exposed or concealed equipment, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping. Minimum height above ceilings shall be 6" clear including insulation, unless otherwise noted.

**PART 25 – BROKEN LINES AND PROTECTION AGAINST FREEZING:**

- 25.1 No conduits, piping, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. Do not install piping across or near openings to the outside whether or not they are carrying static or moving fluids. Insulation on piping does not necessarily ensure that freezing will not occur. If in doubt, contact the Engineer.

**PART 26 – WEATHERPROOFING:**

- 26.1 Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as specified and approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.
- 26.2 Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

**PART 27 – ACCESSIBILITY:**

- 27.1 The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and ceilings for the proper installation of their work. They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.
- 27.2 The Contractor shall locate and install all equipment so that it may be serviced, and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, controls, coils, etc.
- 27.3 Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

**PART 28 – SCAFFOLDING, RIGGING AND HOISTING:**

- 28.1 The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

**PART 29 – CLEANING:**

- 29.1 The Contractor shall, at all times, keep the area of their work presentable to the public and clear from rubbish and debris caused by their operations; and at the completion of the work, they shall remove all rubbish, debris, all of their tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.
- 29.2 After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

- 29.3 Piping shall be kept clean at all times. Piping stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Do not install the piping or insulation if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer may periodically inspect that these procedures are followed.

PART 30 – INSPECTION, APPROVALS AND TESTS:

- 30.1 Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installations to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.
- 30.2 The Contractor shall provide as a part of this Contract any required Agency inspection, licensed and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.
- 30.3 The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing the work. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all rough-in without fail. Failure of the Inspecting Agency to inspect the work in a timely manner and submit the related reports may result in the Contractor having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.
- 30.4 Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.
- 30.5 Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspector to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

PART 31 - ABOVE-CEILING AND FINAL PUNCH LISTS:

- 31.1 The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.
- 31.2 Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.
- 31.3 When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch

list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review. The Contractor's representative may be requested at the inspections.

- 31.4 If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of \$125.00 per hour plus travel expense for extra trips required to complete either of the above ceiling, below ceiling or final punch lists.

#### PART 32 – OPERATING INSTRUCTIONS:

- 32.1 Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of three (3) days of eight (8) hours each, or as otherwise specified. Refer to Section HVAC EQUIPMENT for additional requirements. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.
- 32.2 Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft form, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Refer to Specification Section SHOP DRAWINGS for additional detail.
- 32.3 Each Contractor, in the above mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

#### PART 33 – RECORD DRAWINGS:

- 33.1 The Contractor shall ensure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.
- 33.2 All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State in which the project is being constructed. The survey shall include actual pipe depths to top of pipe every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on a compact disc in AutoCad “.dwg” format and “.pdf” format. The survey information shall be included in the closeout documentation.



PART 34 - COMMISSIONING: CONTRACTOR RESPONSIBILITIES:

- 34.1 Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
- Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
  - Cooperate with the CxA for resolution of issues recorded in the Issues Log.
  - Attend commissioning team meetings.
  - Integrate and coordinate commissioning process activities with construction schedule.
  - Complete electronic construction checklists as Work is completed and provide to the Commissioning Authority.
  - Review and accept commissioning process test procedures provided by the Commissioning Authority.
  - Complete commissioning process test procedures.

END OF SECTION 210500

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## SECTION 210501 - SCOPE OF THE FIRE SUPPRESSION WORK

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE PROTECTION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Fire Suppression work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include but is not necessarily limited to the following paragraphs.
- 1.3 All applicable services and work specified in COMMON WORK RESULTS.
- 1.4 *Installation of all equipment per the manufacturer's instruction, whether specifically detailed or not.*
- 1.5 Provide all required motor starters, etc. not provided under the electrical sections.
- 1.6 Thorough instruction of the Owner's maintenance personnel in the operation and maintenance of all mechanical equipment.
- 1.7 Thorough coordination of the installation of all piping, ductwork, equipment and any other material with other trades to ensure no conflict in installation.
- 1.8 Approved supervision of the scope.
- 1.9 Procurement of all required inspections, including fees for all inspection services and submission of final certificates of inspection to the Engineers.
- 1.10 Excavation, backfilling, cutting, patching, sleeving, concrete work, etc., required to construct the systems.
- 1.11 Equipment and start-up, verification and documentation as specified.
- 1.12 Record drawings, final inspection certificates, test results, O & M documentation, warranty certification, spare parts and other specified closeout documentation.
- 1.13 Required schedule of values breakdown.
- 1.14 Pipe and equipment identifications.
- 1.15 Preinstallation meetings and equipment mockups.
- 1.16 Complete exterior fire protection system connected to the local system/utility.

- 1.17 Complete fire protection service to 5'-0" beyond building footprint. Refer to Civil Drawings/Specifications for additional requirements.
- 1.18 100% automatic sprinkler systems.
- 1.19 Fire pump/jockey pump/controls.
- 1.20 All insulation associated with systems.
- 1.21 Drainage systems.
- 1.22 All required pressure testing, flushing, purging, pressure and flow testing requirements.
- 1.23 Final coordination and connection of all equipment furnished.
- 1.24 All required controls, including self checkout and commissioning.

END OF SECTION 210501

## SECTION 210502 – SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE PROTECTION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 1 requirements for shop drawing submittal requirements.
- 1.3 Provide all shops in electronic/PDF format. The Engineer's comments will be returned in electronic format.
- 1.4 Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.
- 1.5 Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.
- 1.6 All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.
- 1.7 The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.
- 1.8 It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.
- 1.9 The Engineer's review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations and information that pertains to fabrication and installation; dimensions, weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.

- 1.10 Prior to ordering any materials or rough-in of any kind, the Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Prime Contractor, Mechanical Contractor, Electrical Contractor and their sub-contractors.
- 1.11 Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.
- 1.12 If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.
- 1.13 Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.
- 1.14 All submittals for equipment shall include all information specified and scheduled. This shall include water pressure drops, RPM, noise data, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.
- 1.15 All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.
- 1.16 Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

## PART 2 – SHOP DRAWINGS:

- 2.1 Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Access Doors  
Test Reports  
Fire Protection Sprinkler System (2.2.1, 2.2.2, 2.2.3)  
Firestopping (2.2.5)  
Kitchen Rangehood Fire Suppression System (2.2.4)  
System Verification Check Lists  
Controls & Components (2.2.2)  
Valves

(Refer to the corresponding Special Notes.)

2.2 SPECIAL NOTES:

- 2.2.1 For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:
- Detailed operating instructions
  - Detailed maintenance instructions including preventive maintenance schedules.
  - Addresses and phone numbers indicating where parts may be purchased.
  - Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
  - Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.
  - Start-up reports, service records and test reports.
- 2.2.2 Shop drawings for the Fire Suppression Systems shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system.
- 2.2.3 Shop drawings for the Building Fire Protection System shall be prepared and stamped by a Certified Contractor and shall meet the criteria of the authority having jurisdiction and submitted to the Engineer. After the Engineer's review, they shall be submitted by the Contractor to the proper state authorities along with the required agency review fee. Refer to Specification Section – FIRE PROTECTION for additional requirements.
- 2.2.4 The Contractor shall submit shop drawings for the kitchen range hood fire suppression system(s) along with all required supporting documentation agency and review fees to the authority having jurisdiction and receive approval prior to submittal to the Engineer.
- 2.2.5 The Contractor shall submit project specific UL listed firestopping installation drawings to the authority having jurisdiction where required for their approval as required.

END OF SECTION 210502

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## SECTION 210515 - SLEEVING, CUTTING, PATCHING, REPAIRING AND FIRESTOPPING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE PROTECTION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.
- 1.3 The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.
- 1.4 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.
- 1.5 The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.
- 1.6 All work improperly performed or not performed as required in this section, shall be corrected by the General Contractor at the responsible Contractor's expense.

### PART 2 – SLEEVES:

- 2.1 Cast iron or Schedule 40 steel sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking between pipe and sleeve for water proofing. Horizontal sleeves passing through exterior walls or where there is a possibility of water leakage and damage shall be caulked watertight. Utilize "Link-Seal" at these locations.
- 2.2 In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation. Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

- 2.3 Vertical sleeves in roofs shall be flashed and counterflashed with lead (4 lb.) or 16 oz. copper and welded or soldered to piping, lapped over sleeve and properly weather sealed. Where sleeves pass through roof construction, sleeves shall extend minimum of 12" above the roof.

#### PART 3 – CUTTING:

- 3.1 All openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, or angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor and ceiling finishes as well as to provide a fastening means for devices, etc.
- 3.2 The Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, exhaust fans, etc. Prime paint all lintels. Lintels shall be sized as follows:
- 3.2.1 New Openings under 48" in width: Provide one 3½"x3½"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.
- 3.2.2 New Openings over 48" in width: Consult with Structural Engineer.
- 3.3 No cutting shall be performed at location that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.
- 3.4 Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe-cut with a masonry saw.

#### PART 4 – PATCHING, REPAIRING AND FINISHING:

- 4.1 Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer.
- 4.2 Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.
- 4.3 Piping and passing through floors, ceilings and walls in finished areas shall be fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.
- 4.4 Flanged metal collars shall be provided around all pipes at all wall penetrations; both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2" in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

PART 5 – FIRESTOPPING:

- 5.1 Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the authority having jurisdiction if required.
- 5.2 All pipes penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed.
- 5.3 Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material and properly sealed to maintain the rating integrity of the wall, floor or ceilings affected.
- 5.4 Where the installation of ductwork requires the penetration of non-rated floors, the space around the duct or pipe shall be tightly filled with an approved non-combustible material.
- 5.5 The manufacturer of the firestopping materials shall provide onsite training for the installing Contractor. The training session shall demonstrate to the Contractor the proper installation techniques for all the firestopping materials.
- 5.6 Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.
- 5.7 The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
  - One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
  - One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
  - One hour fire rated gypsum wallboard - 3M #5300-MPC7.
  - Two hour fire rated gypsum wallboard - 3M #5300-MPC7.
- 5.8 Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit details for specific applications if this method of firestopping is chosen.

END OF SECTION 210515

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## SECTION 210553 – IDENTIFICATIONS FOR FIRE SUPPRESSION

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE PROTECTION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

### PART 2 – TAGS AND CHARTS:

- 2.1 Provide and install on each valve 1" in size or greater for all mechanical systems a 1.5" diameter circular bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with sequential number identifiers. Number identifiers shall be determined by the Contractor sequentially.
- 2.2 Provide typewritten valve charts indicating each valve identifier, the valves service, normal position and its location. Also furnish one electronic copy on CD in "\*.xls" format. One (1) copy of this chart shall be mounted in suitable frame(s) with clear plastic covers in a conspicuous location in each of the major mechanical rooms. Repeat only main valves which are to be operated in conjunction with operations of more than single mechanical room.
- 2.3 All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified.
- 2.4 Label all control panels and disconnect switches with service and equipment served.

### PART 3 – PIPING IDENTIFICATION:

- 3.1 All piping and ductwork installed shall be identified according to the charts hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping and ductwork installed under this contract. Markers and arrows shall be painted on the piping and ductwork using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. Piping and ductwork shall be identified on twelve (12) foot centers. All piping and ductwork shall be minimally identified once above all room ceilings and where it passes thru walls or floors. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking.
- 3.2 The following table describes the size of the color field and size of the identification letters which shall be used for pipes of different outside pipe diameters.

| Outside Diameter | Label Length | Letter Size |
|------------------|--------------|-------------|
| 3/4" – 1 1/4"    | 8"           | 1/2"        |
| 1 1/2" – 2"      | 8"           | 3/4"        |
| 2 1/2" – 6"      | 12"          | 1 1/4"      |
| 8" – 10"         | 24"          | 2 1/2"      |

- 3.3 The following chart describes the pipe service and label identification which shall be used for various pipes.

| PIPE                         | ABBREVIATION  |
|------------------------------|---------------|
| Fire Protection (STANDPIPE)  | FP STANDPIPE  |
| Fire Protection (Wet System) | WET SPRINKLER |
| Fire Protection (Dry System) | DRY SPRINKLER |

PART 4 – PAINTING OF PIPING:

- 4.1 All piping in the mechanical rooms, shall be completely painted by this contractor.
- 4.2 Piping shall be painted in accordance with the following color coding chart. Verify colors with the Owner prior to painting. Paint all pipes evenly in a workmanlike manner. Apply a minimum of two coats of paint for sufficient coverage.

| PIPE            | PIPE COLOR CODE     | ABBREVIATION |
|-----------------|---------------------|--------------|
| Fire Protection | Red w/White Letters | SEE ABOVE    |

PART 5 – EQUIPMENT IDENTIFICATION:

- 5.1 Unless otherwise specified, all equipment shall be identified. The titles shall be short and concise, and abbreviations may be used as long as the meaning is clear. In finished rooms and mechanical rooms, equipment shall be identified neatly and conspicuously with engraved black lamacoid plates (or equivalent) with 1” high white letters on the front of each piece of equipment.
- 5.2 All equipment and associated starters/disconnects shall have the electrical panel number and circuit number identified on a lamacoid plate. Coordinate with the Electrical Contractor.

PART 6 – ACCESS THROUGH LAY-IN CEILINGS:

- 6.1 Mark each lay-in ceiling panel which is nearest access to equipment, valves, dampers, filters, duct heaters, etc., with colored tape labels located on the ceiling grid.

END OF SECTION 210553

## SECTION 211000 - FIRE PROTECTION SYSTEM

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR FIRE PROTECTION and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 No Contractor, other than those regularly engaged in the installation of approved and franchised automatic sprinkler systems will be considered or approved for the work under this Specification Section. The Contractor shall have not less than five (5) years experience in the fabrication and erection of fire protection systems as specified. The Contractor shall have completed five (5) installations similar and equivalent in scope to the systems specified.
- 1.3 Before submitting bid, examine the Contract Documents, visit the site (if necessary) and become acquainted with all conditions that may, in any way whatsoever, affect the execution of this work. The Contractor shall take their own measurements and be responsible for exact size and location of all openings required for installation of this work. Figured dimensions where indicated are reasonably accurate and should govern in setting out work. Detailed method of installation is not indicated. Where variations exist between described work and approved practice, the Engineer shall be consulted for directive.
- 1.4 It is the intent of the Plans and Specifications to provide a general layout only and locate major equipment, components, piping, etc. Variations in head locations, pipe routing, etc., shall be anticipated by the Contractor and shall be coordinated with all other trades and indicated on the drawings and descriptive literature called for hereinafter. It shall be the express responsibility of the Contractor to provide all required design, materials and equipment and perform all work required to install a complete and approved installation.
- 1.5 All materials and methods shall be in accordance with applicable codes, regulations and/or ordinances and meet approval of local inspection authority and the State Fire Marshal. Also, all work shall comply with the latest editions of the National Board of Fire Underwriters, National Fire Protection Association, OSHA Regulations, the International Building Code, the Life Safety Code, International Mechanical Code and governing building codes. All materials and equipment installed as a part of this work shall be listed by the Underwriters Laboratories, Inc. as approved for fire protection installations.
- 1.6 Where flow and pressure data are available, they are indicated on the project drawings. The Contractor shall independently verify all such information and notify the Engineer of any discrepancies discovered prior to beginning the work. Where no flow information is indicated on the project drawings, the Contractor shall obtain the data and indicate it on the shop drawing submittal. All flow information obtained shall be less than six (6) months old. Piping systems shall be hydraulically sized based on the most conservative flow information obtained. No adjustments in the contract amount will be allowed for failure of the Contractor to obtain adequate flow information.
- 1.7 The Contractor shall obtain the all-flow data and produce the hydraulic calculations for the sprinkler system. The flow and hydraulic calculations shall be indicated in the shop drawing

submittal along with posting on the main sprinkler risers (each zone, dry system and wet system riser).

- 1.8 All sprinkler piping shall be concealed above ceilings. Coordinate all ceiling related work with the architectural reflected ceiling plans. This includes but is not limited to the following: ceiling height changes, soffits, headers, lights, diffusers, grilles, speakers, cameras, fire alarm devices, etc. Refer to the architectural, electrical, and mechanical drawings for additional information.
- 1.9 The Owner's local insuring agency may review plans prepared and submitted by the Contractor but shall have no authority to make changes once work has begun. Coordinate with the Owner prior to construction.
- 1.10 All work performed under this section shall be accomplished in close harmony with all other trades. All work not so coordinated shall be removed and reinstalled at the expense of the Contractor.
- 1.11 The Contractor shall list the following cost breakdowns, material and labor, on the official project schedule of values:
  - Fire Protection Shop Drawings and Approvals
  - Fire Protection Materials & Labor
  - Fire Protection Record Drawings & Acceptance

#### PART 2 – SCOPE OF WORK:

- 2.1 Furnish all material, labor, tools, equipment and supervision required for installation of a complete and new fire protection system as indicated on the project drawings and within these specifications. Include all necessary piping, sprinkler heads, test connections, valves, drains, etc.
- 2.2 The Contractor shall provide flushing and sterilization of all water lines in accordance with current Codes, Rules and Regulations and shall make connection to domestic water mains in accord with current rules and regulations of the State Department of Sanitary Engineering and Division of Water.
- 2.3 The Contractor shall obtain and pay for all necessary state, municipal, county, city and other permits and fees and pay all State taxes which are applicable.
- 2.4 All workmanship, equipment and material shall be guaranteed in writing against defects from any cause, other than misuse, for a period of one year from substantial completion.
- 2.5 Upon completion, the Contractor shall submit to the Engineer, a properly completed "Sprinkler Contractor's Certificate Covering Materials and Tests" form.
- 2.6 Upon completion of this work all debris, material, and equipment shall be removed from the building and premises; all piping shall be cleaned ready for finish painting. Do not remove rust inhibitive primer specified hereinafter.

#### PART 3 – SHOP DRAWINGS:

- 3.1 The Contractor shall prepare and submit to the Engineer, shop drawings including design calculations, detailed catalog cutsheets and layout drawings indicating the proposed automatic



sprinkler system. All layouts and drawings shall be closely coordinated by the Contractor with the work of ALL other trades. The shop drawings shall indicate the following items:

- Name and address of Owner, Architect and Engineer.
- Sprinkler heads including temperature rating.
- Fire department connection.
- Post indicator valve.
- Detector check valves.
- Wet pipe alarm valves and wet system specialties.
- Flanged gate and check valves.
- Pipe hangers.
- Supervised O.S & Y valve.
- The pressure sensing switch.
- The post indicator supervisory switch (coordinated with the Fire Alarm Contractor).
- The main gate valve supervisory switch (coordinated with the Fire Alarm Contractor).
- The flow switch (coordinated with the Fire Alarm Contractor).

3.2 On a set of drawings to the same scale as the drawings accompanying these specifications, indicate:

- Each head location coordinated with lights, diffusers and other ceiling mounted device.
- Location of all risers, mains, runout lines, etc.
- Size of all risers, mains, runout lines, etc.
- Location and type of pipe hangers.
- All other information required by the Authority Having Jurisdiction providing approval.

3.3 The Contractor shall submit these shop drawings to the Engineer through the General Contractor and Architect for their review and approval. The Contractor shall submit the reviewed drawings to the Authority Having Jurisdiction for their review and approval. The Contractor shall incorporate all review comments from the Engineer and the Authority Having Jurisdiction. No work shall be performed onsite until all review processes are complete and updated drawings are on the job site.

#### PART 4 – EQUIPMENT AND MATERIALS:

4.1 EXTERIOR PIPE & FITTINGS: Class 200 PVC piping for exterior fire protection piping. Piping shall meet AWWA C900 requirements, be UL listed, Factory Mutual approved and NSF approved. Joints shall have spigot pipe ends with a flexible elastomeric ring seated in a groove to provide water tight seal. Minimum burst pressure to be 900 psi when tested in accordance with ASTM D1599. No. 8 copper wire (tracer wire) shall parallel all piping.

4.2 POST INDICATOR VALVE: Furnish and install a post indicator valve as required by the local authority. It shall be listed and approved by Underwriters Laboratories and Associated Factory Mutual Laboratories; Marked SV-FM; vertical; non-adjustable; with electric supervisory switch, handle, view window, brass padlock with two (2) keys; gate valve to meet gate valve specifications, except to have non-rising stem and mechanical joint ends; equivalent to Mueller, Scott or Lunkenheimer.

4.3 DETECTOR CHECK VALVE: Furnish and install detector check valve as required by the local authority. It shall be listed and approved by Underwriter Laboratories and Associated Factory

- Mutual Laboratories; 175# working pressure; IBBM; flanged; with tapped bosses each side for by-pass meter trimming; equivalent to Viking, Badger or Grinnell.
- 4.4 The Contractor shall contact the servicing water company and ascertain their policy pertaining to the bypass water meter. If not furnished by water company, the Contractor shall furnish and install the bypass meter and trimming as detailed on the drawings.
- 4.5 FIRE DEPARTMENT CONNECTION: Furnish and install a fire department connections with threads as approved by the local fire department; cast brass polished and chromium plated; with connection sizes and lettering as directed by the local authority having jurisdiction; Viking, Automatic Sprinkler Corporation, or approved equivalent.
- 4.6 WET ALARM VALVES: All alarm valves must be UL and FM approved. Alarm valve shall have a grooved seat design with retarding chamber. Valve shall be rated for 175 PSI working pressure. Valve shall be provided with external bypass line and drain valve. Reliable, Gem, Grinnell, Star, Viking or approved equal.
- 4.7 FLOW INDICATOR SWITCHES: Furnish and install flow indicator switches as required by NFPA 13. All flow indicator switches shall be UL approved. Coordinate with Fire Alarm System supplier/installer.
- 4.8 TAMPER SWITCHES FOR WATER SHUT-OFF VALVES: Furnish and install tamper switches where required by NFPA 13. All tamper switches shall be UL approved. Coordinate with Fire Alarm System supplier/installer. All tamper switches located in fire protection pits shall be waterproof, capable of operating beneath water and be NFPA approved.
- 4.9 GATE VALVES: 2½" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; OS&Y; flanged; cast iron discs; bronze seat rings; four point wedging mechanism; equivalent to Mueller, Scott or Lunkenheimer. 2" and under; 150# working pressure; bronze; rising stem; screwed; bronze discs; bronze seat rings; two point wedging mechanism; equivalent to Jenkins, Scott or Lunkenheimer.
- 4.10 CHECK VALVES: 2½" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; flanged; equivalent to Mueller, Scott or Lunkenheimer. 2" and under; 150# working pressure; bronze; screwed; equivalent to Jenkins, Scott or Lunkenheimer.
- 4.11 INTERIOR PIPE & FITTINGS: Up to 2" Schedule 40 ASTM A-53 black steel; 125# cast iron screwed fittings or Schedule 40, ASTM A-53 black steel with victaulic or similar type approved fittings. 2½" and larger: Schedule 40 black steel with flanged, welded or victaulic (or similar) type approved fittings.
- 4.12 Do not route sprinkler piping (including drops) directly above any light fixtures. Do not route sprinkler piping near ceiling; hold tight to structure. Where large volumes occur above ceiling route pipe at least 36" above ceiling. The Sprinkler Contractor shall coordinate during design of sprinkler systems to insure these requirements are met.
- 4.13 SPRINKLER HEADS: Tyco, Viking, Reliable: All sprinkler heads shall be fed in a reverse bend arrangement. Sprinkler head degree ratings shall be determined by the area serviced in accord with current Codes and Standard Practices. Sprinkler heads shall be flush, concealed type on

public spaces such as restrooms, corridors, areas located in gym space, storage rooms, and as indicated on the drawings. Types of sprinkler heads shall be as follows:

- Semi-Recessed, Quick Response – Reliable (or equal) Model F1FR-300 semi-recessed automatic sprinkler head. Escutcheon and head shall be white.
- Upright, Quick Response – Reliable (or equal) Model F1FR Vertical Upright automatic sprinkler head.
- Sidewall, Quick Response – Reliable (or equal) Model GFR, horizontal sidewall automatic sprinkler head.
- Concealed, Quick Response – Reliable (or equal) Model G4A Concealed automatic sprinkler head. Cover shall be white.
- Caged, Pendent, Quick Response – Reliable (or equal) Model F1FR Vertical Upright automatic sprinkler head with D1 cage. These heads shall be used in the multipurpose (Gym) area.
- High Temperature Heads: Viking Micromatic 286 degrees F rated blue bulb heads.

- 4.14 At the Contractor's option, extended coverage sprinkler heads may be used where appropriate.
- 4.15 At the Contractor's option, code approved flexible sprinkler heads may be used where appropriate and in compliance with the installation requirements of these specifications.
- 4.16 Where sprinkler heads are installed in a tile ceiling, they shall be installed in the middle of the tiles, at half or quarter points along the length of the tiles.
- 4.17 Coordinate sprinkler head locations in kitchen freezer/cooler units with light fixtures and other ceiling mounted devices to insure proper coverage is maintained. Provide these heads with cages. Seal freezer/cooler panels where pipe penetrations occur.
- 4.18 CLAMPS AND ANCHORS: Furnish and install approved clamps, as required, at all (45 degree) 1/8 bends, (90 degree) 1/4 bends and flange and spigot pieces to the straight pipe to insure permanent anchorage of all fire lines. Fittings, clamps, clamp rods, nuts, washers, and glands shall be factory zinc-coated.
- 4.19 HANGERS: All piping shall be adequately and permanently supported in an approved manner on approved hangers. Supporting and hanging shall be done so that excessive load will not be placed on any one hanger or structural member and as required to allow for proper pitch and expansion of piping. Minimally support piping on 8 foot intervals for pipe 3" and smaller; 10 foot intervals for larger piping. Also support within 24" of changes in direction and end of runs.
- 4.19.1 Refer to Structural General Note 5.24 on S001. Hangers with less than 100# may eccentrically load the bar joist with "C clamps". Hangers greater than 300# and must concentrically load (i.e.- no "C clamps") the top or bottom chord. This 300# must include impact load factors. If the 300# load limit can't be attained then the hangers must hit at a joist panel point location and load the joist concentrically. The concentrically loaded term means the rod must come up the gap between the chords.
- 4.19.2 All major hangers (loads greater than 100 lbs) at structural floors must attach to the steel members and not into the slab. Minor hangers (loads less than 100#) may go into the slab.

- 4.19.3 All hangers attached to wood members must go into the upper half of the member and not into the bottom soffit or the lower half of the sides.
- 4.20 SLEEVES AND ESCUTCHEON PLATES: Furnish and install sleeves for pipes where piping penetrates masonry walls; exterior wall sleeves to be watertight. Fire and smoke stop all penetrations through fire and smoke walls and coordinate with General Contractor for locations. Furnish and install cast brass chrome plated split ring type escutcheons where piping penetrates walls, ceilings and floors, whether in finished areas or not.
- 4.21 INSPECTION TEST CONNECTIONS & PRESSURE GAUGES: A 1" inspection test connection as required by the Building Code. Discharge shall run to open air. Control valve for test connection shall be installed not over 7' above the floor. A pressure gauge at the inspection. Test connection at each location indicated on the Plans. Pressure gauges shall be 2½" diameter and readable from the floor.
- 4.22 SIGNS: Appropriate code approved and required signs shall be installed on all control valves, drains, inspector's test, etc., indicating the function, installation, etc. Signs shall be neatly affixed with rust inhibitive screws, rivets or where hung from piping; with stainless steel No. 14 AWG wire.
- 4.23 SPRINKLER HEAD CABINET: Furnish and install a cabinet, clearly labeled, with four (4) sprinklers of each type complete with required wrenches. Locate as directed by Engineer. Label "Sprinkler Heads".

#### PART 5 – SYSTEM DRAINAGE:

- 5.1 The entire System except that part which is below grade and will not freeze shall be installed so as to allow 100% drainage.
- 5.2 All sprinkler branch piping shall be installed so as to drain back to the main riser.
- 5.3 Approved 2" drawoff piping shall be provided on sprinkler risers with discharge piping running to nearest floor drain or open air.
- 5.4 Where sprinkler piping is trapped, an approved auxiliary draw-off shall be provided and neatly installed.
- 5.5 All draw-offs shall have a metal tag labeled "Sprinkler Drain".

#### PART 6 – INSPECTIONS AND TESTS:

- 6.1 Furnish all labor, equipment and conduct all required tests in the presence of the Owner and Engineer or designated representative if requested. Coordinate with Owner and Engineer prior to testing.
- 6.2 All interior and exterior piping and devices comprising the fire protection system shall be tested under hydrostatic pressure of not less than 200 PSI and maintained for not less than two (2) hours. Any leaks or cracks developing as a result of these tests shall be repaired to the satisfaction of the Owner.

- 6.3 Upon completion of their work, the Contractor shall submit a written and signed certificate to the Engineer indicating that they performed the above prescribed tests and rectified all malfunctions arising therefrom.

END OF SECTION 211000

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## SECTION 220100 – COMMON WORK RESULTS FOR PLUMBING

### PART 1 – GENERAL:

- 1.1 The General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.
- 1.2 All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals to any part if for work, services, materials or equipment to be used on or applied to this project are hereby directed to familiarize themselves with all documents of Contract Documents. In case of conflict between these Common Work Results and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination prior to the Bid.
- 1.3 The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Plumbing Systems indicated or specified in the Contract Documents.
- 1.4 Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete any part of the Plumbing Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.
- 1.5 It is not the intent of this Section of the Specifications to make any Contractor, other than the General Contractor, responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the General Contractor to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.
- 1.6 The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer's convenience and is not intended to define a subcontractor's scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Plans and Specifications when preparing Bids, prices and quotations.
- 1.7 This Section of the Specifications or the arrangement of the contract documents shall not be construed as an attempt to arbitrarily assign responsibility for work, material, equipment or services to a particular trade Contractor or Sub-Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.
- 1.8 It is the intent of the Contract Documents to deliver to the Owner a new, complete and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or

relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

- 1.9 In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least forty-eight (48) hours prior to the interruption of any services. The Owners shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.
- 1.10 Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Contractor's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation to the Owner, except where otherwise provided for in the contract for the work.
- 1.11 Each Contractor shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.
- 1.12 Definitions and Abbreviations:
- Contractor - Any Contractor whether bidding, proposing or working independently or under contract with General Contractor, or Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the General Contractor.
  - Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
  - Architect - The Architect of Record for the project.
  - Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, General and Special Conditions, Addenda, Alternates, Unit Prices, Shop Drawings, Field Orders, Change Orders, Construction Contract with Owner, and other documents enumerated in the Owner/Contractor Agreement.
  - Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.
  - The Project - All of the work required under this Contract.
  - Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
  - Provide - Furnish and install complete, tested and ready for operation.
  - Install - Receive and place in satisfactory operation.
  - Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto or incorporated in the contract documents by reference.
  - Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
  - ADA - Americans with Disabilities Act.
  - ANSI - American National Standards Institute.
  - ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.
  - ASME - American Society of Mechanical Engineers.
  - IBC - International Building Code.
  - NEC - National Electrical Code.



- NEMA - National Electrical Manufacturers Association.
- NFPA - National Fire Protection Association.
- OSHA - Office of Safety and Health Administration.
- SMACNA - Sheet Metal and Air Conditioning Contractors National Association.
- UL - Underwriters Laboratories.

## PART 2 – INTENT AND INTERPRETATION:

- 2.1 It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included in the contract sum.
- 2.2 Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
- 2.3 The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.
- 2.4 The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

## PART 3 – INDEMNIFICATION:

- 3.1 Refer to Project General Conditions and Supplementary Conditions.
- 3.2 The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

## PART 4 – PLANS AND SPECIFICATIONS:

- 4.1 The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Plans are not intended to show every item which may be necessary to complete the

- systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.
- 4.2 The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.
- 4.3 The Plans and Specifications shall be considered to be complimentary and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
- 4.4 Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.
- 4.5 The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.
- 4.6 Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.
- 4.7 Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to ensure no conflict with other work.
- 4.8 Each Bidder/Proposer shall review all Plans in the Contract Documents to ensure that the work they intend to provide does not create a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular ensure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to ensure adequate spaces.
- 4.9 Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.
- 4.10 Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

- 4.11 Where within the Contract Documents the word “typical” or “typ.” is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.
- 4.12 Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.

#### PART 5 – EXAMINATION OF SITE AND CONDITIONS:

- 5.1 Each Bidder/Proposer shall inform their self of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.
- 5.2 Each Bidder/Proposer shall also fully acquaint their self with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

#### PART 6 – EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

- 6.1 When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.
- 6.2 Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; unless specifically indicated, any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of cities, towns, states or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

- 6.3 Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Owner utilizing Procurement Substitution Requests or Substitution for Cause as indicated in Division 01 specifications.
- 6.4 Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.
- 6.5 Ten (10) days prior to the submission of a proposal, each Bidder/Proposer shall give written notice to the Engineer of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted. In the absence of such written notice, Bidder/Proposers signify that they have included the cost of all required items in the proposal and that the Bidder/Proposer will be responsible for the safe and satisfactory operation of the entire system.

**PART 7 – CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:**

- 7.1 The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, inspections and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.
- 7.2 Ignorance of Codes, Rules, Regulations, Laws, etc. shall not render the Contractor irresponsible for compliance. The Contractor shall also be versed in all Codes, Rules and Regulations pertinent to their part of the work prior to submission of a proposal. Refer to Drawings for applicable codes.
- 7.3 The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus and Plans in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.
- 7.4 All materials furnished and all work installed shall comply with the latest version National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.
- 7.5 All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of, or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.
- 7.6 All plumbing work is to be constructed and installed in accordance with applicable codes, Plans and Specifications which have been approved in their entirety and/or reflect any changes

requested by the State Department of Health. Plumbing work shall not commence until such Plans are in the possession of the Plumbing Contractor.

- 7.7 The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.
- 7.8 Where minimum code requirements are exceeded in the Design, the Design shall govern.
- 7.9 The Contractor shall ensure that their work is accomplished in accord with the OSHA Standards and that they conduct their work and the work of their personnel in accord with same.
- 7.10 All work relating to the handicapped shall be in accord with regulations currently enforced by the Department of Housing, Buildings and Construction, Commonwealth of International and the American Disabilities Act.
- 7.11 Discharge of any toxic, odorous or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.
- 7.12 Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense. The provisions of the codes constitute minimum standards for wiring methods, materials, equipment and construction and compliance therewith will be required for all electrical work, except where the Plans and Specifications require better materials, equipment, and construction than these minimum standards, in which case the Plans and Specifications shall be the minimum standards.

#### PART 8 – QUALIFICATIONS OF CONTRACTOR/WORKERS:

- 8.1 All Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.
- 8.2 All plumbing subcontractors bidding the plumbing work must have completed at least one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.
- 8.3 All plumbing work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workers and unqualified or incompetent workers shall refrain from work in areas not deemed satisfactory. Requests for relief of a workers shall be made through the normal channels of Architect, Contractor, etc.
- 8.4 All plumbing work shall be accomplished by licensed contractors with Journeymen or Master Plumbers as defined under State Plumbing Law Regulations and Code.

- 8.5 The installation of all Heating, Ventilating and Air-Conditioning Systems (HVAC) by any Contractor shall be performed by a Licensed Contractor with Journeymen or Master Tradesmen as defined under State Regulations and Code. This includes any Contractor installing HVAC systems, piping and ductwork.
- 8.6 All automatic control systems shall be installed by workers normally engaged or employed in this type work.
- 8.7 All special systems (Automatic Sprinkler Equipment, etc.) shall be installed only by workers normally engaged in such services. Exception to this specification may only be made in writing by the Engineer.
- 8.8 All electrical work shall be accomplished by licensed contractors with Journeymen or Master Electrician as defined under State Regulations and Code. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

#### PART 9 – SUPERVISION OF WORK:

- 9.1 The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

#### PART 10 – CONDUCT OF WORKERS:

- 10.1 The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt relief of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or debilitating drugs on the job site is strictly forbidden.

#### PART 11 – COOPERATION AND COORDINATION WITH OTHER TRADES:

- 11.1 The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.
- 11.2 Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than  $\frac{1}{4}'' = 1'-0''$ , clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.
- 11.3 The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

PART 12 – GUARANTEES AND WARRANTIES:

- 12.1 The Contractor shall guarantee all equipment, apparatus, materials, performance, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective for a minimum of two years in addition to the time frames outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Engineer's Statement of Substantial Completion. Items of equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.
- 12.2 All compressors shall have five year warranty (5 year parts and labor).
- 12.3 Provide all warranty certificates to Owner. All warranties begin starting at the substantial completion date, submit warranty certificates accordingly.

PART 13 – COST BREAKDOWNS (SCHEDULE OF VALUES):

- 13.1 Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.
- 13.2 The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding (minimum of ½ % of associated mechanical contract value installation scope) for startup, testing, documentation, acceptance, owner training, etc.:
- Shop Drawings
  - Motor Load Coordination with other subcontractors
  - Record Drawings & Acceptance
  - O&M Manuals & Acceptance
  - Owner Training & Acceptance
  - Startup, Testing, Management Plan, Documentation, Acceptance, Owner Training, etc.
  - Identification Materials & Labor
  - Insulation (Piping) Materials & Labor
  - Materials & Labor
  - Piping Purging, Flushing, Cleaning
  - Plumbing Fixtures and Equipment
  - Plumbing Materials, Piping & Labor
  - Plumbing Shop Fabrication
  - Water to Water Heat Pump Equipment & Labor
  - Water to Water Heat Pump Startup, Testing, Documentation, Training, Acceptance, etc.
  - Controls Startup, Testing, Documentation, etc.

- Controls Training and Acceptance
- Test and Balance Materials & Labor
- Test and Balance Initial Report, Final Report and Acceptance

13.3 Provide to the engineer the following unit prices to determine any adjustment to the contract price due to changes in work or extra work performed under this contract. The unit prices shall include the furnishing of all labor and materials, cost of all items, and overhead and profit for the Contractor, as well as any subcontractor involved. These unit prices shall be listed in units of work.

- 4" Exterior Sch 40 PVC Sanitary, including trenching and backfill. (Unit: LF)
- 2" Copper Type L domestic water piping, installed with insulation, hangers, etc. (Unit: LF)
- 1-1/2" Copper Type L domestic water piping, installed with insulation, hangers, etc. (Unit: LF)
- 1" Copper Type L domestic water piping, installed with insulation, hangers, etc. (Unit: LF)

#### PART 14 – CHANGES IN WORK:

14.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

#### PART 15 – CLAIMS FOR EXTRA COST:

15.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

#### PART 16 – MATERIALS AND WORKMANSHIP:

16.1 All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and this work shall be the responsibility of the Contractor. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Ensure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.

16.2 Materials and equipment, where applicable, shall bear Underwriters' Laboratories label where such a standard has been established.

16.3 Use extreme care in the selection of equipment and its installation to ensure that noise and vibration are kept at a minimum. The Engineer's determination shall be final and corrections to such discrepancies shall be made at the cost of the Contractor.

16.4 Each length of pipe, fitting, trap, fixture and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.

16.5 All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a data plate indicating required horsepower, voltage, phase and ampacity. Pumps shall have a data plate indicating horsepower, static pressure head and flow rate.



**PART 17 – HAZARDOUS MATERIALS:**

- 17.1 The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building or site.
- 17.2 Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall ensure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.
- 17.3 CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.
- 17.4 If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.
- 17.5 The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.
- 17.6 No asbestos or mercury containing materials shall be installed in this project.
- 17.7 It is the policy of the Owner that no asbestos - containing materials are to be purchased by the Owner, supplied by any person supplying to the Owner or installed in or on Owner property by any person performing work for the Owner. Furthermore, all products marked "May contain Mineral Fiber" will be assumed to contain asbestos unless the manufacturer provides written certification that no asbestos fibers are present in the product and identifies the fibers for which the product is marked. An exception to this rule can be made where a faculty or staff member certifies that the use of asbestos is essential to an ongoing research or production project and works with Environmental Health and Safety Department to ensure that the material is used, stored and disposed of in safe and legal manner.

**PART 18 – COORDINATION DRAWINGS:**

- 18.1 Detailed coordination drawings shall be required for this project. A specific line-item shall be included on the schedule of values by each Trade for "preparation of coordination drawings". The Construction Manager shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.
- 18.2 Coordination Drawings shall be provided on this project by each Trade (Mechanical, Plumbing, Fire Protection, Electrical). Drawings shall be 30x42 sheet size and shall be at 1/4" scale and shall

match the drawing setup as included in the Architectural Drawings. The Architect and Engineer may supply electronic drawings files of the Contract Documents upon the Contractor's request and release.

- 18.3 The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits and other conduits 2" and larger, heat pump system piping and other major components in the ceiling cavity. The Coordination Drawings shall be prepared by the Mechanical Contractor with cooperation of all the contractors. The Coordination Drawings shall indicate (1) systems above ceilings in finished areas, (2) systems supported from the structure in finished areas without ceilings, (3) systems in the mechanical rooms, and (4) all wall, roof, floor penetrations. These drawings shall indicate all ductwork as double lined with bottom elevations noted.
- 18.4 The sheet metal fabrication shop drawings shall be completed in a timely manner so as not to conflict with construction schedule and phasing plan. At the Contractor's discretion, these drawings shall be completed in phases to correspond with the project construction work sequencing. The Mechanical Contractor shall furnish an electronic copy of these ductwork shop drawings to all other Trades, specifically the Fire Protection and Electrical and other Contractors as requested by the Construction Manager and General Contractor for the purpose of including other trades work on the Coordination Drawings.
- 18.5 Pre-Coordination Meetings with all necessary trades should be performed. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc will be installed with respect to the sheetmetal fabrication drawings and other trades. The sheetmetal ductwork and gravity piping systems shall be given the first priority. Within 30 days of the meeting, each Trade shall provide the Mechanical Contractor electronic drawings of all of their systems (with elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings may be required so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at the Construction and Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.
- 18.6 It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
- All supply/return/exhaust ductwork.
  - All above slab sanitary and roof drainage piping.
  - HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
  - Electrical conduits which are 1.5" in size and greater.
  - Cable tray and bridal ring paths.
  - Multiple smaller piping/conduits hung on a common trapeze hanger.
  - All wall, roof, floor penetrations.
- 18.7 After completion of the Final Coordination Drawings, a Final Review with the all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meeting will be required to ensure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed electronically (on CD) to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete 30x42 paper set

of drawings to the jobsite main office and shall utilize them for updates of field conditions/deviations that occur during construction. Final Approved Coordination Drawings shall also be distributed to the Contractor, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.

- 18.8 Each Contractor shall ensure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on Coordination Drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Contractor, Owner, Architect and Engineer for their Records.
- 18.9 The mechanical contractor is responsible to the general contractor for the shop drawing layout of the following rooms and details:
- Concrete pads and foundations
  - Equipment room layouts with actual equipment
  - Roof layouts
  - Trench locations and sizes
  - Dimensioned floor drain locations
  - Congested areas above ceilings adjacent to mechanical and electrical room
  - Dimensioned ductwork shop drawings

#### PART 19 – TEMPORARY SERVICES:

- 19.1 The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.
- 19.2 All temporary services shall be removed by Contractor prior to acceptance of work.

#### PART 20 – SURVEY, MEASUREMENTS AND GRADE:

- 20.1 The Contractor shall lay out their work and be responsible for all necessary lines, levels, elevations and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.
- 20.2 The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.
- 20.3 Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

#### PART 21 – PROTECTION OF EQUIPMENT:

- 21.1 The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged stolen or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense. All ductwork with open ends shall be covered with plastic during construction.

#### PART 22 – REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:

- 22.1 The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, ductwork, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost.

#### PART 23 – EQUIPMENT SUPPORT:

- 23.1 Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

#### PART 24 – PIPE MOUNTING HEIGHTS:

- 24.1 All exposed or concealed piping, equipment, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping and ductwork shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping above ceiling.

#### PART 25 – BROKEN LINES AND PROTECTION AGAINST FREEZING:

- 25.1 No conduits, piping, troughs, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. If in doubt, contact the Engineer. Do not install piping across or near openings to the outside whether they are carrying static or moving fluids or not. Insulation on piping does not necessarily ensure that freezing will not occur.

#### PART 26 – WEATHERPROOFING:

- 26.1 Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.

- 26.2 Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

PART 27 – FINAL CONNECTIONS TO EQUIPMENT:

- 27.1 The Contractor shall finally connect plumbing services (water, sanitary, gas, air, etc.), any terminal equipment, appliances, kitchen equipment, etc., provided under this and other divisions of the work. Various equipment connections indicated are based upon “basis of design” equipment selections. Should alternate equipment be purchased by the General Contractor, then this Contractor shall make the necessary provisions in the Bid for any and all differences. Change Orders shall not be considered for any differences due to alternate equipment purchase. Such connections shall be made in strict accord with current codes, safety regulations and the equipment manufacturer’s recommendations. If in doubt, contact the Engineer prior to installation.

PART 28 – ACCESSIBILITY:

- 28.1 The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and hung ceilings for the proper installation of their work. They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.
- 28.2 The Contractor shall locate and install all equipment so that it may be serviced, and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, etc.
- 28.3 Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

PART 29 – SCAFFOLDING, RIGGING AND HOISTING:

- 29.1 The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

PART 30 – CONCRETE WORK:

- 30.1 The Contractor shall be responsible for the provisions of all concrete work required for the installation of any of their systems or equipment. The Contractor may, at their option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of their responsibilities relative to dimensions, quality of workmanship, locations, etc. In the absence of other concrete Specifications, all concrete related to Mechanical work shall be 3500 psi minimum compression strength at 28 days curing and shall conform to the standards of the American Concrete Institute Publication ACI-318. Heavy equipment shall not be set on pads for at least

seven (7) days after pour. Insert 6-inch steel dowel rods into new and existing floors to anchor pads.

- 30.2 All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18" in width shall be reinforced with ½" round bars on 6" centers both ways. Bars shall be approximately 3" above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all vertical edges ¾" and tool horizontal edges with ¾" radius.
- 30.3 In general, concrete pads for equipment shall extend six (6) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

#### PART 31 – RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:

- 31.1 The Contractor shall at their expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, landscaping, existing or new building surfaces and appurtenances, and any other items damaged or removed by their operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Owner and/or Engineer.

#### PART 32 – MAINTENANCE OF EXISTING UTILITIES AND LINES:

- 32.1 The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily. Provide a seven (7) day written notice to Engineer, Architect and Owner prior to interrupting any utility service or line.
- 32.2 Known utilities and lines as available to the Engineer are shown on the Plans. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Contractor shall bear costs of repairing damaged utilities.
- 32.3 If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation in the respective area.
- 32.4 Cutting into existing utilities and services shall be done in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.
- 32.5 The Contractor shall repair to the satisfaction of the Owner and Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

- 32.6 Machine excavation shall not be permitted with ten feet of gas lines, fuel lines, electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only in accord with utility company, agency or other applicable laws, standards or regulations.
- 32.7 Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.
- 32.8 Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

#### PART 33 – CLEANING:

- 33.1 The Contractor shall, at all times, keep the area of their work presentable to the public and clean of rubbish and debris caused by their operations; and at the completion of the work, shall remove all rubbish, debris, all of their tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.
- 33.2 After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.
- 33.3 Piping shall be kept clean at all times. Piping stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Do not install the piping if the building is not "dried-in". If this is required, the entire lengths of piping shall be covered in plastic to protect. The Owner/Engineer may periodically inspect that these procedures are followed.

#### PART 34 – EQUIPMENT/CONTROLS STARTUP & VERIFICATION:

- 34.1 The Contractor shall include in the bid to provide equipment and controls startup and verification for ALL Plumbing Systems specified for this project.
- 34.2 Specific startup/verification Specifications are included throughout the Mechanical Specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians, not third party contractors, and shall complete and submit start-up reports/checklists. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up. All information shall be completed by the Contractor and submitted to the Owner/Engineer prior to acceptance of the equipment.
- 34.3 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment.

Unless noted otherwise, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include the following:

- Water-to-Water Domestic Water Heat Pump Units (Use the attached forms – no exceptions)
- Variable Frequency Drives
- Water Flow Meters/BTUH Meters

- 34.4 Except for the equipment specified in this Specification Section, the manufacturer's recommended startup procedures and checklists will be acceptable for use in the project. Where "manufacturer" startup is not specified, then this Contractor shall perform startup services in strict accordance with manufacturer's instructions. All startup/verification process shall be thoroughly documented by the Contractor and shall include the time and date when performed.
- 34.5 The Contractor shall "zip-tie" a start-up report to each piece of equipment in a clear plastic cover. Once start-up completion is verified by the Engineer the Contractor shall remove all reports and consolidate them into close-out documentation. The Contractor shall be responsible for completion of System Verification Checklist (SVC) / Manufacturer's Checklists. Furnish to the Testing Agent and Engineer. Sample checklists shall be submitted to the Engineer, Owner, and Testing Agent for approval.

#### PART 35 - INSPECTION, APPROVALS AND TESTS

- 35.1 Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installation to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.
- 35.2 The Contractor shall provide as a part of this Contract any required Agency inspection, licensed and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.
- 35.3 The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing work. Failure of the Inspecting Agency to inspect the work in the stage following and submit the related reports may result in the Contractor's having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.
- 35.4 Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all roughing-in without fail. Report of each such Agency Inspection visit shall be submitted to the Architect, Engineer and the Contractor within three days of the inspection.
- 35.5 Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.
- 35.6 Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspectors to the Engineer with one copy of each to



the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

#### PART 36 - ABOVE-CEILING AND FINAL PUNCH LISTS:

- 36.1 The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.
- 36.2 Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.
- 36.3 When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review. The Contractor's representative may be requested at the inspections.
- 36.4 If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of \$100.00 per hour for extra trips required to complete either of the above ceiling, below ceiling or final punch lists.

#### PART 37 - OPERATING INSTRUCTIONS:

- 37.1 Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of three (3) days of eight (8) hours each, or as otherwise specified. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.
- 37.2 Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions.
- 37.3 Each Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

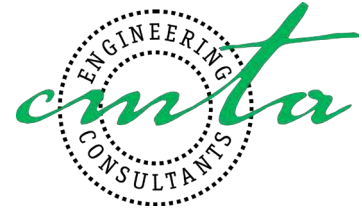
#### PART 38 - RECORD DRAWINGS:

- 38.1 The Contractor shall ensure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record

documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.

- 38.2 All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State. This shall include underground geothermal piping mains, vaults and vertical bore locations. The survey shall include actual pipe depths to top of pipe every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on a compact disc in AutoCad “.dwg” format and “.pdf” format.
- 38.3 The survey information shall be included in the closeout documentation.

**WATER-TO-WATER HEAT PUMP UNIT  
SYSTEM VERIFICATION CHECKLIST**



**Project:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Tag:** \_\_\_\_\_ **Time:** \_\_\_\_\_

**Area Served:** \_\_\_\_\_ **Technician:** \_\_\_\_\_

**Contractor:** \_\_\_\_\_

| <i>Water-to-Water Heat Pump Unit</i>                                             | √ | <i>Comments</i> |
|----------------------------------------------------------------------------------|---|-----------------|
| <b>Preliminary Checklist</b>                                                     |   |                 |
| Verify Correct Model Installed #                                                 |   |                 |
| Voltage and Power Supply Correct per Name Plate                                  |   |                 |
| Phasing is Correct Per Compressor Rotation(2)                                    |   |                 |
| Max Overcurrent Protection Correct                                               |   | Fuse Size       |
| Verify Electrical Disconnect Location & Accessibility with<br>Lamecoid Nameplate |   |                 |
| Test Disconnect Switch                                                           |   |                 |
| Low Voltage Wiring Correct- Controls                                             |   |                 |
| Verify Water Flow Through Unit                                                   |   |                 |
| Check, Clean and Note Strainer Condition                                         |   |                 |
| Verify Unit installed on Concrete Pad                                            |   |                 |
| Insulation installed and piping labeled                                          |   |                 |
| Unit Labeled                                                                     |   |                 |
| Verify Piping Installation per Schematic                                         |   |                 |
| -Pressure Relief Valve                                                           |   |                 |
| -Thermometers                                                                    |   |                 |
| -Pipe size –Supply/Return to Unit                                                |   |                 |
| -Flexible Hose Kits                                                              |   |                 |
| -Pete's Plug                                                                     |   |                 |
| -Pressure Gauges                                                                 |   |                 |
| -Control Valves Installed & Operational                                          |   |                 |
| -All Valves/Strainers/Check Valves                                               |   |                 |
|                                                                                  |   |                 |
| <b>Start Up</b>                                                                  |   |                 |
| Attach Start Up Report from Manufacturer Representative                          |   |                 |

END OF SECTION 220100

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## SECTION 220300 - SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 1 requirements for shop drawing submittal requirements.
- 1.3 Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.
- 1.4 Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.
- 1.5 All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.
- 1.6 The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.
- 1.7 It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.
- 1.8 The Engineer's review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations and information that pertains to fabrication and installation; dimensions, weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.
- 1.9 Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract

Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Prime Contractor, Mechanical Contractor, Electrical Contractor and their sub-contractors.

- 1.10 Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.
- 1.11 If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.
- 1.12 Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.
- 1.13 All submittals for mechanical equipment shall include all information specified and scheduled. This shall include air and water pressure drops, RPM, noise data, face velocities, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.
- 1.14 All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.
- 1.15 Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

## PART 2 – SHOP DRAWINGS:

- 2.1 Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Access Doors  
Firestopping (2.2.3)  
Floor Drains (2.2.1)  
Insulation  
Plumbing Fixtures, Fittings and Trim (2.2.1)  
Plumbing Specialties (2.2.1)  
Pumps and Hydronic Specialties (2.2.1)  
Roof Drains (2.2.1)  
System Verification Check Lists  
Controls & Components (2.2.2)  
Valves (2.2.1)  
Variable Frequency Drives (2.2.1)  
Water-to-Water Heat Pump Units (Water Heaters and Tanks) (2.2.1)

(Refer to the corresponding Special Notes.)

2.2 SPECIAL NOTES:

- 2.2.1 For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:
- Detailed operating instructions
  - Detailed maintenance instructions including preventive maintenance schedules.
  - Addresses and phone numbers indicating where parts may be purchased.
  - Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
  - Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.
  - Start-up reports, service records and test reports.
- 2.2.2 Shop drawings for the Temperature Control Systems shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system. Refer to Specification Section – CONTROLS for additional requirements.
- 2.2.3 The Contractor shall submit project specific UL listed firestopping installation drawings to the authority having jurisdiction.

END OF SECTION 220300

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## SECTION 220513 – COMMON MOTOR ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section – HVAC EQUIPMENT for additional requirements. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.
- 1.3 Review the Specification Section – TEMPERATURE CONTROLS AND SEQUENCE OF OPERATIONS FOR HVAC to determine controls, including variable frequency drives, to be furnished.
- 1.4 Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, General Contractor, Mechanical Contractor, Electrical Contractor and their sub-contractors.

### PART 2 - MOTORS:

- 2.1 The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications and drawing schedules.
- 2.2 Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
- 2.3 Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
- 2.4 Motors shall be capable of frequency of starts as indicated by automatic control system and not less than five (5) evenly time spaced starts per hour for manually controlled motors.
- 2.5 Motors shall have a 1.15 service factor for poly-phase motors and 1.35 service factor for single phase motors.
- 2.6 Motors shall have a temperature rating for 40 deg C ambient environment with maximum 90 deg C temperature rise for continuous duty at full load with 1.15 service factor and Class B insulation.
- 2.7 Unless otherwise noted or required by application, motors shall conform to NEMA Standard MG 1 (Table 12-10) for general purpose, continuous duty, horizontal, T-frame, single speed, design "A" or "B". Utilize design "C" motors where required for high starting torque.

- 2.8 Motor frames shall be NEMA Standard No. 48 or 56. Use driven equipment (fans, pumps, etc.) manufacturer's standards to suit specific application.
- 2.9 Motor bearings shall be ball or roller bearings with inner and outer shaft seals. Bearings shall be re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance. Bearings shall be designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
- 2.10 Motor enclosure type shall be open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation. Enclosures shall be guarded drip-proof type motors where exposed to contact by employees or building occupants. Enclosure shall be weather protected Type I for outdoor use or Type II where not housed.
- 2.11 Provide built-in thermal overload protection and, where required, internal sensing device suitable for signaling and stopping motor at starter.
- 2.12 Provide energy efficient motors with a minimum efficiency in accordance with NEMA MG 1, Table 12-10 for 1800 rpm, enclosed motors.
- 2.13 On the motor nameplate, indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

#### PART 3 - ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT:

- 3.1 All plumbing equipment shall be provided for single point electrical connection unless noted otherwise.
- 3.2 The equipment manufacturer shall provide internally mounted fuses with his equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends or requires fuse protection.) See also, National Electrical Code, Article 440, Part C, and other applicable sections of the N.E.C.
- 3.3 It shall be the Contractor's responsibility to assure that all plumbing equipment requiring electrical connections be provided with all required proper wiring, electrical protective devices, disconnecting means and electro-mechanical starting units to properly match the mechanical equipment requirement.
- 3.4 Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per Code and Project requirements.
- 3.5 Equipment with internal compressors shall be furnished with integral starter.
- 3.6 All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of this Contractor.

- 3.7 All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.
- 3.8 Observe the following standards for manufacture of equipment and in selection of components: (1) Starters, control devices and assemblies - NEMA (I.E.C. style not acceptable), (2) Enclosures for electrical equipment – NEMA, (3) Enclosed switches – NEMA, (4) All electrical work, generally NFPA 70, (5) All electrical work in industrial occupancies - J.I.C. standards, (6) All electrical components and materials - U.L. listing required.
- 3.9 Where scheduled on the drawings, provide disconnect switches and contactors. Disconnect switches shall be fusible type or circuit breaker type.

#### PART 4 - REQUIREMENTS FOR MECHANICAL EQUIPMENT 3/4 H.P. OR LESS:

- 4.1 This section describes requirements for small plumbing equipment such as pumps.
- 4.2 Small equipment with motor(s) of 3/4 H.P., single phase or less are generally not required to be furnished with starter(s), unless otherwise noted. For such equipment, provide integral contactor or horsepower-rated relay where controlled by DDC controls, thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment.
- 4.3 Provide transformer within unit as required to provide low voltage A.C. for thermostat control.
- 4.4 Provide internal fusing for unit motor and other loads in fuse block or in-line fuseholder.
- 4.5 Where externally-mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction.

END OF SECTION 220513

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## SECTION 220517 – SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.
- 1.3 The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to go through; however, when this is not done, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the buildings by the workers of the responsible Contractor must be corrected or rectified at their own expense.
- 1.4 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete or masonry. Set all concrete inserts and sleeves for their work. Failing to do this, Contractor shall cut openings for the work and patch same as required at their own expense.
- 1.5 The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.
- 1.6 All work improperly performed or not performed as required by the Mechanical Trades in this section, shall be corrected by the General Contractor at the responsible Contractor's expense.

### PART 2 – SLEEVES:

- 2.1 Cast iron or Schedule 40 steel sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking between pipe and sleeve for water proofing. Utilize "Link-Seal" at these locations.
- 2.2 In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation.
- 2.3 Horizontal sleeves passing through exterior walls or where there is a possibility of water leakage and damage shall be caulked watertight. Utilize "Link-Seal" at these locations.
- 2.4 Vertical sleeves in roofs shall be flashed and counterflashed with lead (4 lb.) or 16 oz. copper and welded or soldered to piping, lapped over sleeve and properly weather sealed. Where sleeves

pass through roof construction, sleeves shall extend minimum of 12" above the roof.

- 2.5 Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

#### PART 3 – CUTTING:

- 3.1 All rectangular or special shaped openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, wood or metal angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor and ceiling finishes as well as to provide a fastening means for grilles, diffusers, louvers, etc.
- 3.2 The Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, wall boxes, exhaust fans, etc.). Lintels shall be sized as follows:
- 3.2.1 New Openings under 48" in width: Provide one 3½"x3½"x3/8" LLV steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.
- 3.2.2 New Openings over 48" in width: Consult with structural engineer.
- 3.3 No cutting is to be done at points or in a manner that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.
- 3.4 Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe cut with a masonry saw.

#### PART 4 - PATCHING AND REPAIRING:

- 4.1 Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade or trades for work cut or damaged. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer and Owner.
- 4.2 Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.
- 4.3 Piping passing through floors, ceilings and walls in finished areas shall be fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.
- 4.4 Flanged metal collars shall be provided around all flues, pipes, etc. at all wall penetrations; both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2" in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

## PART 5 - FIRESTOPPING:

- 5.1 The Contractor shall submit project specific UL listed firestopping installation drawings to the local building inspectors for their approval as required. Acceptable manufacturers include Hilti, 3M, Metacaulk or equal. Coordinate firestopping systems with other trades. Refer to LS103 for additional information.
- 5.2 All mechanical pipes penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed. Piping materials shall be as required for the UL listed assembly.
- 5.3 Where the installation of conduit, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material satisfactory to maintain the rating integrity of the wall, floor or ceilings affected.
- 5.4 Where the installation of piping requires the penetration of non-rated floors, the space around the duct or pipe shall be tightly filled with an approved non-combustible material.
- 5.5 Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the local building inspector.
- 5.6 The manufacturer of the firestopping materials shall provide on site training for the installing Contractor. The training session shall demonstrate to the Contractors the proper installation techniques for all the firestopping materials. Contact the Engineer prior to conducting this training session.
- 5.7 Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.
- 5.8 The following indicates the 3M penetration detail for uninsulated pipe penetration of various wall and floor construction types:
  - 5.8.1 One or two hour fire rated concrete floor - 3M #5300-MPC8.
  - 5.8.2 One or two hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
  - 5.8.3 One hour fire rated gypsum wallboard - 3M #5300-MPC7.
  - 5.8.4 Two hour fire rated gypsum wallboard - 3M #5300-MPC7.
- 5.9 The following indicates the 3M penetration detail for insulated pipe penetrations of various wall and floor construction types:
  - 5.9.1 One or two hour fire rated concrete floor - 3M #5300-IMP2.

- 5.9.2 One or two hour concrete block wall - 3M #5300-IMP2.
- 5.9.3 One hour fire rated gypsum wallboard - 3M #5300-IMP4.
- 5.9.4 Two hour fire rated gypsum wallboard - 3M #IMP7.
- 5.10 Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit UL listed details for specific applications if this method of firestopping is chosen.

END OF SECTION 220517



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## SECTION 220519 – METERS AND GAGES FOR PLUMBING PIPING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall include all thermometers, pressure gauges and/or compound gauges at the locations indicated. All thermometers, pressure gauges and/or compound gauges shall be provided with "PET Cocks" to allow the gauge to be removed and replaced without shutting down system.

### PART 2 – THERMOMETERS AND PRESSURE GAUGES:

- 2.1 Gauges and thermometers shall be Marsh, Marshalltown, Trerice, or Weksler.
- 2.2 All thermometers and pressure gauges shall be readable from a standing position on the floor. Mount thermometers in approved wells. Do not make direct contact of base with fluid in pipe. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc. with flexible tubing.
- 2.3 Digital thermometers shall be WIKA Type T1.D01, solar powered industrial thermometer. The range shall be -50°F/300°F with an accuracy of 1% or 1°, whichever is greater. The display shall be a 3/8" LCD digit. Use where specifically indicated on the drawings.
- 2.4 Water thermometers shall be Bimetal type with 3" dial, stainless steel case, stainless steel stem and socket with length as required by piping system. Accuracy to be plus or minus 1%. Lens to be plastic. Water thermometers shall have a 25°F to 125°F range.
- 2.5 Pressure gauges shall be Bourdon Type, circular, 2-1/2" face, black letters on white face graduated in 2 PSI or less and shall be manufactured for service intended. Provide with pig tail connectors and gauge cocks. Accuracy to be plus or minus 2%. Water pressure gauges shall have 0 to 100 PSI range.
- 2.6 Provide direct mount Bimetal dial thermometers in HVAC ductwork. Thermometer shall be 4" diameter, with acrylic plastic lens and stainless steel case. Air temperature range shall be 25°F to 125°F.

### PART 3 – PRESSURE/TEMPERATURE PORT (PETE'S PLUG – P/T PLUG):

- 3.1 Provide 1/4" NPT fitting to receive either a temperature or pressure probe, 1/8" OD. Fitting shall be solid brass with two valve cores. Valve core material to be neoprene for temperatures up to 200°F and Nordel for temperatures between 200°F and 275°F. Pete's Plugs to have 3" length when installed on insulated pipes and 1-1/2" length for uninsulated pipes. Pete's Plug to be fitted with a color-coded cap strap with gasket and shall be rated at 1000 PSIG at 140°F.

- 3.2 The installing contractor shall supply the owner (4) pressure gauges with 1/8" OD probe and (4), five-inch stem pocket testing thermometers rated for 25-125°F water and 4, 0-200°F water thermometers.

END OF SECTION 220519

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## SECTION 220523 – GENERAL DUTY VALVES FOR PLUMBING PIPING

### PART 1 – GENERAL:

#### 1.1 RELATED SECTIONS:

- 1.1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.1.2 Each Contractor shall provide all valves required to control, maintain and direct flow of all fluid systems indicated or specified. This shall include but may not be limited to all valves of all types including balancing valves, air vents, drain valves, check valves, special valves for special systems, etc., for all Mechanical Systems.
- 1.2 ACCEPTABLE MANUFACTURERS: Lunkenheimer, Powell, Nibco, Crane, Jenkins, T & S Brass, Walworth, Milwaukee, DeZurik, Consolidated Valve Industries, Inc., Bell & Gossett, Apollo.
- 1.3 The following type valves shall not be acceptable: Zinc, plastic, fiber or non-metallic.
- 1.4 Each type of valve shall be of one manufacturer, i.e., ball valves, one manufacturer, butterfly valves, one manufacturer, check valves, one manufacturer, etc.
- 1.5 All valves shall comply with current Federal, State and Local Codes. All valves shall be new and of first quality. All valves shall be designed and rated for the service to which they are applied. Zinc, plastic, fiber or non-metallic valves shall not be acceptable.
- 1.6 Contractor shall provide colored tape on ceiling tile where valves are located above ceiling. Provide access panels where valves are located above hard ceiling.

### PART 2 – SITE WATER APPLICATIONS:

- 2.1 TAPPING SLEEVES: Tapping sleeves for connection to existing water mains shall be of the mechanical joint type suitable for working pressures of 150 psi and shall be Mueller No. H-615, American-Darling No. 1004, M&H 1174, or approved equal. Tapping sleeves for connection to existing pipe shall be suitable for the appropriate type of pipe to be tapped. Contractor shall be responsible for uncovering and determining type, class and the exact O.D. of the pipe to be tapped prior to ordering material.
- 2.2 IN-LINE GATE VALVE: Gate valve shall be resilient seated, manufactured to meet or exceed the requirements of the latest revision of AWWA C-509, "Resilient-Seated Gate Valves, 3 through 12 NPS, for Water and Sewage Systems" suitable for water working pressures of 200 psi. Valves shall have a non-obstructed waterway that is equal to or greater than the full nominal diameter of the valve so as to not restrict any flow through the valve. The valves are to be non-rising stem with the stem made of cast, forged, or rolled bronze. Two stem seals shall be provided and shall be of the o-ring type. All Resilient-Seated Gate Valves shall be Mueller A-2370-20 or approved equal.

- 2.3 TAPPING GATE VALVES: All tapping valves shall conform to the latest revisions of AWWA C-500 "AWWA Standards for Gate Valves for Ordinary Water Works Service". All tapping valves shall be of the double disc, parallel seat type, iron body, non-rising stem, fully bronze mounted and suitable for water working pressures of 200 psi. All tapping valves shall be furnished with mechanical joint end connections, unless otherwise shown on the drawings or specified hereinafter and shall be compatible with the tapping sleeve used. All tapping valves shall be Mueller H-667 or approved equal.
- 2.4 CHECK VALVE: All check valves shall conform to the latest revisions of AWWA C-508. All check valves shall be iron body, bronze mounted, and rated for 175 psi. All check valves shall have the name or monogram of the manufacturer, the year the valve casting was made, the size of the valve, and the working water pressure cast on the body of the valve. All check valves 2 - 1/2" through 12" shall be of the outside lever and weight design and shall be equal to Mueller A-2600-6-01 for flanged connections and/or Mueller A-2600-20-01 for mechanical joint connection.
- 2.5 VALVE BOXES: Valve boxes shall be of 5 - 1/2" inch standard cast iron two-piece, screw type valve box with drop cover marked "WATER". They shall be of sufficient height to allow them to be raised an additional two (2) inches above the final elevation at each location that a valve box is required on this project. PVC and iron pipe sleeves will not be allowed.

### PART 3 – DOMESTIC WATER APPLICATIONS:

- 3.1 GATE VALVE (2" AND UNDER): Use ball valves as specified.
- 3.2 GATE VALVE (2½" AND LARGER): Gate valve shall have bronze body, bonnet and solid wedge. Gate valve shall be rising stem with bolted bonnet and solid wedge. Valve shall have rated for 150 psi working pressure. Gate valve shall be Nibco T-134 for threaded ends or Nibco S-134 for solder ends.
- 3.3 GLOBE VALVES (2" AND UNDER): Globe Valves shall have bronze body, bonnet and disc holder. Globe valve shall have union bonnet, integral seat, teflon or stainless steel renewable disc and be rated for 150 psi working pressure. Globe valve shall be Nibco T-235 for threaded ends or Nibco S-235 for solder ends.
- 3.4 CHECK VALVE (2" AND UNDER): Check valve shall have bronze body, disc and hinge. check valve shall be Y-pattern type, horizontal swing, renewable disc and rated for 150 psi working pressure. Check valve shall be Nibco T-413 for threaded ends or Nibco S-413 for solder ends.
- 3.5 BALL VALVES (2½"-3"): Ball valve shall have bronze body, ball and reinforced, watertight seat. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-580 for threaded ends and Nibco S-580 for solder ends. Provide extended handles for all ball valves installed in an insulated system.
- 3.6 THREE PIECE BALL VALVE (2" AND UNDER): Ball valve shall have bronze body, ball and reinforced, water tight seat. Valve shall be three piece, swing-out, construction to facilitate inspection and repair. Valve shall be "full-port" type. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve

- shall be rated for 180 degrees F water temperature and 150 psi working pressure. Ball valve shall be Nibco T-595 for threaded ends and Nibco S-595 for solder ends.
- 3.7 STRAINERS (2" AND UNDER): Watts 77S Series "Y" type strainer with cast iron body and threaded ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with cleanout plug and be rated for 200 psi working pressure.
- 3.8 STRAINERS (2½" AND LARGER): Watts 77F Series "Y" type strainer with semi-steel body and flanged ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with bolted cleanout and be rated for 200 psi working pressure.
- 3.9 PRESSURE REDUCING VALVES: Watts #U5B water pressure reading valve with bronze body, bolted bonnet, integral stainless-steel strainer and outlet water pressure gauge. Internal disc, diaphragm and stainless-steel seat shall all be removable. Valve shall be rated for inlet water pressures up to 300 psi. Water pressure reducing valves shall be provided for all equipment where water pressure exceeds the equipment manufacturer's ratings.
- 3.10 VACUUM BREAKERS: Watts #288A atmospheric type vacuum breaker with brass body. Vacuum breaker shall be rated for 210 degrees F and 125 psi working pressure and shall meet ASSE Standard 1001.
- 3.11 DOUBLE CHECK VALVE: Double check valve shall have bronze body construction and be provided with inlet strainer, two (2) gate valves for isolation and three (3) test ports. Assembly shall be rated for 110 degrees F water temperature and 175 psi water pressure. Assembly must meet requirements of AWWA Standard C506. For sizes 2" and less, provide Watts #900 (or equal) with threaded ends. For sizes 2½" and larger, provide Watts #709 (or equal) with flange ends.
- 3.12 REDUCED PRESSURE BACKFLOW PREVENTERS: Reduced pressure backflow preventers shall be provided with inlet strainer, two (2) gate valves for isolation, three (3) test ports and air gap fitting. Assembly shall be rated for 110 degrees F water temperature and 175 psi water pressure. RBPB shall be UL listed and meet AWWA C511 standards. Watts #909 or equal by Wilkins or Conbraco. All valves 3" and less in size shall bronze body construction, over 3" in size shall have epoxy coated cast iron bodies. Assemblies 2" and under in size shall have threaded ends, over 2" in size shall have flange ends. Perform backflow preventer test and provide results with closeout documentation.

END OF SECTION 220523

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## SECTION 220529 – HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 This section includes, but is not limited to, furnishing and installing dampers, supports, anchors, and accessories for piping, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work.
- 1.3 Power driven anchors and expansion anchors shall be permitted only when permission is granted in writing by the Architect and Engineer.

### PART 2 – MATERIALS AND EQUIPMENT:

- 2.1 Hangers, Clamps, Attachments Schedule:
  - ACCEPTABLE MANUFACTURERS: Grinnell, Elcen, Fee & Mason.
  - All hangers, clamps and attachments shall be manufactured products.
  - Pipe Rings (2" pipe and smaller) – adjustable swivel split ring or split pipe ring.
  - Pipe Clevis (2.5" pipe and larger) – adjustable wrought clevis type.
  - Pipe Clevis (All pipe sizes) – steel clevis for insulated pipe.
  - Riser Clamps (All pipe sizes) – extension pipe or riser clamp.
  - Beam Clamps (All pipe sizes) – malleable beam clamp with extension piece.
  - Brackets (All pipe sizes) – medium weight steel brackets.
  - Concrete Inserts (All pipe sizes) – wrought or wedge type inserts.
  - Concrete Fasteners (All pipe sizes) – self-drilling concrete inserts.
  - Rod Attachments (All pipe sizes) – extension piece, rod coupling, forged steel turnbuckle
  - U-bolts (All pipe sizes) – standard u-bolt.
  - Welded Pipe Saddles (All pipe sizes) – pipe covering protection saddle sized for thickness of insulation.
  - Pipe Roll (All pipe sizes) – adjustable swivel pipe roll.
  - Protection Saddle (All pipe sizes) – 180 degree coverage, sheet metal pipe protection saddle.
  - Hanger Rods (All pipe sizes) – Steel, diameter of hanger threading.
  - Concrete Channel Inserts (All pipe sizes) – continuous heavy duty slot inserts unistrut.
  - Adjustable Spot Inserts (All pipe sizes) – continuous heavy duty spot insert unistrut.
  - Miscellaneous steel such as steel angles, rods, bars, channels, etc used in framing for supports, fabricated brackets, anchors, etc. shall confirm to ASTM-A-7.

### PART 3 – INSTALLATION:

- 3.1 Unless otherwise specified, all supporting, hanging and anchoring of piping, equipment, etc., shall be performed by each trade as is necessary for completion of the work and shall be as directed in the following paragraphs.
- 3.2 Supporting and hanging shall be done so that excessive load will not be placed on any one hanger or structural member and as required to allow for proper pitch and expansion of piping.

- 3.2.1 Refer to Structural General Note 5.24 on S001. Hangers with less than 100# may eccentrically load the bar joist with "C clamps". Hangers greater than 300# and must **concentrically** load (i.e.- no "C clamps") the top or bottom chord. This 300# must include impact load factors. If the 300# load limit can't be attained, then the hangers must hit at a joist panel point location and load the joist concentrically. The concentrically loaded term means the rod must come up the gap between the chords.
- 3.2.2 All major hangers (loads greater than 100 lbs) at structural floors must attach to the steel members and not into the slab. Minor hangers (loads less than 100#) may go into the slab.
- 3.2.3 All hangers attached to wood members must go into the upper half of the member and not into the bottom soffit or the lower half of the sides.
- 3.3 Hangers and supports shall be placed as near as possible to joints, turns and branches.
- 3.4 For concrete construction, utilize adjustable concrete inserts for fasteners. Expansion anchors and power-driven devices may be used when approved in writing by the Architect/Engineer.
- 3.5 Utilize beam clamps for fastening to steel joists and beams and expansion anchors in masonry construction.
- 3.6 When piping is routed in joists, piping shall be top mounted on trapeze type hangers with each pipe individually clamped to trapeze hanger. Do not support piping or ductwork from bridging angles.
- 3.7 Trapeze hangers are not allowed, unless specifically submitted and reviewed by the Engineer. Submit detailed calculations.
- 3.8 Install all miscellaneous steel other than designed building structural members as required to provide means of securing hangers, supports, etc., where piping does not pass directly below or cross steel joists.
- 3.9 Piping shall not be supported by the equipment to which it is connected. Support all piping so as to remove any load or stress from the equipment.
- 3.10 Where piping, etc., is routed vertically, approved riser clamps, brackets or other means shall be utilized at approximately 10'-0" center to center minimum and an approved adjustable base stand or fitting on concrete support base shall be utilized at the base of the vertical run.
- 3.11 Where piping is routed along walls, knee braced angle frames, etc. pipe brackets with saddles, clamps, and rollers mounted on structural brackets fastened to walls or columns shall be used.
- 3.12 Support all ceiling hung equipment with approved vibration isolators.
- 3.13 Where copper tubing is specified, hangers shall be of copper clad type when piping is uninsulated.



- 3.14 Uninsulated piping hung from above shall be supported with ring and clevis type pipe hangers. Uninsulated piping mounted on trapeze and wall bracket type support shall be held in place with U-bolts. U-bolts shall allow for axial movement in the piping.
- 3.15 All insulated piping shall be supported with clevis type and pipe roll hangers. Hangers shall be sized to allow the pipe insulation to pass through the hangers. Install insulation protection saddles at all hanger locations. Welded pipe saddles shall be installed at all hangers on piping 5" and larger. The pipe saddles shall be sized for the thickness of insulation used. Hangers shall fit snugly around outside of insulation saddles.
- 3.16 Under no conditions will perforated band iron or steel wire driven hangers be permitted.
- 3.17 Support steel and copper piping at a minimum of eight (8) foot intervals for piping 3" and smaller and ten (10) foot intervals for larger piping. Provide additional support at end of the branches and change of direction.
- 3.18 Support plastic pipe at intervals at a minimum of six (6) foot intervals for piping 4" and smaller; support a minimum of eight (8) foot intervals for larger piping. Smaller plastic piping systems, 2" and smaller, supports shall not to exceed four (4) feet. Support all piping at the end of the branches and at the change of direction and shall be installed as to permit freedom of movement. Vertical piping shall be supported at their bases and all upward movement shall not be restricted. Hangers shall be at least one (1) inch wide and shall not compress, distort, cut or abrade the piping to allow free movement at all times. In addition, all piping installation shall conform to manufacturer's installation instructions.
- 3.19 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants. Reference 230529 for additional piping support requirements.
- 3.20 Ensure that all bolts and nuts are tightened.

END OF SECTION 220529

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## SECTION 220553 – IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

### PART 2 – TAGS AND CHARTS:

- 2.1 Provide and install on appropriate valves on the mechanical system a valve tag made of bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed with an identifier. IdentifierS shall be determined by the Contractor. Identifiers include bypass valves, normally open/normally closed valves, zone isolation, etc.
- 2.2 Provide in the operation manual valve tag information indicating valve identifier, the valves service, normal position and its location.
- 2.3 All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified as any valve whose closure could create an emergency condition in the facility (i.e. water, domestic hot water, main plumbing valves, etc.).
- 2.4 Label all control panels and disconnect switches with service and equipment served.

### PART 3 – PIPING IDENTIFICATION:

- 3.1 All piping installed shall be identified according to the chart hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping installed under this contract. Markers and arrows shall be painted on the piping using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. Piping shall be identified on twelve (12) foot centers. All piping shall be minimally identified once above all room ceilings and where it passes thru walls or floors. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking.
- 3.2 The following table describes the size of the color field and size of the identification letters which shall be used for pipes of different outside pipe diameters.

| Outside<br>Diameter | Label<br>Length | Letter<br>Size |
|---------------------|-----------------|----------------|
| ¾" – 1 ¼"           | 8"              | ½"             |
| 1 ½" – 2"           | 8"              | ¾"             |
| 2 ½" – 6"           | 12"             | 1 ¼"           |
| 8" – 10"            | 24"             | 2 ½"           |
| Over 10"            | 24"             | 3 ½"           |

- 3.3 The following chart describes the pipe service and label identification which shall be used for various pipes.

| PIPE                   | ABBREVIATION |
|------------------------|--------------|
| Domestic Cold Water    | D.C.W.       |
| Domestic Hot Water     | D.H.W.       |
| Recirculated Hot Water | D.R.H.W.     |
| Sanitary Sewer Piping  | SAN          |
| Sanitary Vent Piping   | VENT         |
| Storm Sewer Piping     | STORM        |

#### PART 4 – PAINTING OF PIPING:

- 4.1 All insulated and uninsulated piping in the mechanical rooms, shall be completely painted by this contractor.
- 4.2 All piping shall be painted in accordance with the following color coding chart. Verify colors with the Owner prior to painting. Paint all pipes evenly in a workmanlike manner. Apply a minimum of two coats of paint for sufficient coverage.

| PIPE                   | PIPE COLOR CODE        | ABBREVIATION    |
|------------------------|------------------------|-----------------|
| Domestic Cold Water    | Purple w/White Letters | D.C.W.          |
| Domestic Hot Water/HWR | Brown w/White Letters  | D.H.W./D.R.H.W. |
| Sanitary Sewer Piping  | Grey With No Letters   |                 |
| Sanitary Vent Piping   | Grey With No Letters   |                 |
| Storm Sewer Piping     | Grey With No Letters   |                 |

- 4.3 Equipment shall be factory painted white or light gray.
- 4.4 Where a pipe is not specifically identified in this table, painting and marking shall be in accordance with the most recent ANSI Standards.

#### PART 5 – EQUIPMENT IDENTIFICATION:

- 5.1 Unless otherwise specified, all equipment shall be identified. The titles shall be short and concise and abbreviations may be used as long as the meaning is clear. In finished rooms and mechanical rooms, equipment shall be identified neatly and conspicuously with engraved black lamacoid plates (or equivalent) with 1" high white letters on the front of each piece of equipment.
- 5.2 All mechanical equipment shall have the electrical panel number and circuit number identified on the lamacoid plate. Coordinate with the Electrical Contractor.

PART 6 – ACCESS THROUGH LAY-IN CEILINGS:

- 6.1 Mark at each location of the lay-in ceiling panel, on T-bar, which is nearest access to equipment, valves, dampers, etc., with flexible vinyl tape with pressure sensitive adhesive backing and printed markings (P-touch labels) with name of scheduled device (i.e. - VAV, valve, damper, etc...). Coordinate labeling (device name, type, etc.) with Owner.

END OF SECTION 220553

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## SECTION 220700 – PLUMBING INSULATION, EQUIPMENT AND PIPING

### PART 1 – GENERAL:

#### 1.1 RELATED SECTIONS:

- 1.1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 Work under this section shall include all labor, equipment, accessories, materials and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.
- 1.3 Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.
- 1.4 Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.
- 1.5 Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.
- 1.6 Insulation shall comply with UL GREENGUARD which provides independent third party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.
- 1.7 All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.
- 1.8 The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

### PART 2 – MANUFACTURERS:

- 2.1 ACCEPTABLE MANUFACTURERS: Manville, Keene Corp., Knauf, Owens-Corning, Armstrong, World Industries.

### PART 3 – MATERIAL STANDARDS:

- 3.1 Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50 and Fuel Contributed 50.

- 3.2 All products and their packaging shall bear a label indicating above requirements are not exceeded.
- 3.3 Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.
- 3.4 Products shall not contain formaldehyde, asbestos, lead, mercury, or mercury compounds if possible. Products shall be Certified UL GREEGUARD Gold or Indoor Advantage Gold.
- 3.5 Insulation materials applied to carbon steel shall be Mass Load Corrosion Rate (MLCR) tested per ASTM 1617.
- 3.6 Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- 3.7 Basis-of-Design Product: Subject to compliance with requirements, provide Knauf Insulation; Earthwool 1000 Degree Pipe Insulation with ECOSE Technology or Earthwool Redi-Klad 1000 Degree Pipe Insulation with ECOSE Technology. Type I, 850 Deg F (454 Deg C) or Type IV 1000 Deg F (528 Deg C)
- 3.8 Materials: Glass Mineral Wool bonded with a thermosetting resin. EPD Certified by UL Environment, UL/ULC Classified for Earthwool Pipe; FHC 25/50 per ASTM E 84 for Redi-Klad. Living Building Challenge - Declare Red List Free for Redi-Klad Pipe; or unjacketed Earthwool Pipe only. Comply with ASTM 585, ASTM C 411, ASTM C795, and ASTM C 547, Type I, and Type IV, with factory-applied ASJ+-SSL+ or ASJ-SSL.

#### PART 4 – GENERAL APPLICATION REQUIREMENTS:

- 4.1 Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping or equipment until tested, inspected and released for insulation.
- 4.2 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.
- 4.3 All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe is to be located a sufficient distance from walls, other pipe, and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.
- 4.4 "Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Piping and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered as "exposed".



- 4.5 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced as directed by the Engineer.
- 4.6 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples thru the jacket. NO EXCEPTIONS!
- 4.7 All insulation shall be installed with joints butted firmly together.
- 4.8 The Contractor shall insure that all insulation (piping, equipment, etc.) is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (air, water, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.
- 4.9 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

#### PART 5 – PIPING SYSTEMS:

- 5.1 Seal insulation and jacket at all points where insulation terminates at unions, flanges, valves and equipment. This applies to hot water lines only as cold-water lines require continuous insulation and vapor barrier.
- 5.2 Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over is, etc. to insure no condensation drip or collection.
- 5.3 Valves, flanges and unions shall only be insulated when installed on piping whose surface temperature will be at or below the dew point temperature of the ambient air.
- 5.4 Insulation shall not extend through fire and smoke walls. Pack sleeve at fire and smoke wall with approved fire retardant packing similar to mineral wool.
- 5.5 Metal insulation shields and inserts are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180 ° arc. Insulation shields shall be the following size:

| Pipe<br>Size | Shield<br>Gauge | Shield<br>Length |
|--------------|-----------------|------------------|
| 2" and less  | 20              | 12"              |
| 2 ½"- 4"     | 18              | 12"              |
| 5"- 10"      | 16              | 18"              |
| Over 10"     | 14              | 24"              |

- 5.6 Insulated pipes 2" in diameter and larger shall be additionally supported with wood inserts of sufficient compressive strength to carry the weight of the pipe and fluid. Inserts shall extend beyond extend beyond the hanger and shall be at least 6" in length.
- 5.7 Provide premolded PVC insulated fitting covers on all pipe fittings, flanges, valves and pipe terminations. Fittings shall be insulated by applying the proper factory precut insulation insert to the pipe fitting. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipe

fitting. The proper thickness of insulation must be applied to keep the jacket temperature less than 150°F. An approved vapor retarder mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover shall then be applied and secured with pressure sensitive tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side. On fittings where the operating temperature is below 50°F, two or more layers of the insulation inserts shall be applied with the first layer being secured with a few wrappings of fiber glass yarn to eliminate voids. One additional insert shall be used for each additional 1" of pipe insulation above 1-1/2". All joints shall be fully sealed.

- 5.8 PIPE INSULATION MATERIAL: Insulation shall be Owens-Corning model 25ASJ/SSL or approved equivalent fiberglass pipe insulation with an all-service jacket. The insulation shall be a heavy density, pipe insulation with a K factor not exceeding 0.27 Btu per inch/h.ft<sup>2</sup> °F at 75°F mean temperature. The insulation shall be wrapped with a vapor barrier jacket. The jacket shall have an inside foil surface with self sealing lap and a water vapor permeability of 0.02 perm/inch. All circumferential joints shall be vapor sealed with butt strips. All insulation shall be installed in strict accordance with the manufacturer's recommendations. The following pipes shall be insulated with the thickness of insulation as noted.

- 5.8.1 Domestic Cold Water: 1" thick insulation
- 5.8.2 HVAC Fill Lines: 1" thick insulation
- 5.8.3 Exterior HVAC Fill Lines: 1" thick insulation with heat trace jacketing
- 5.8.4 Domestic Hot Water & Return Lines:
  - Piping 1-1/4" and less: 1" thick insulation
  - Piping 1-1/2" and greater: 1-1/2" thick insulation

#### PART 6 – MECHANICAL EQUIPMENT:

- 6.1 STORAGE TANKS: Owens-Corning "Thermal Insulating Wool - Type II" or approved equivalent. Insulation shall be constructed of non-combustible, flexible wool. Insulation shall be 2" thick.  $K = 0.24 \text{ Btu in/hr.ft}^2 \text{ °F @ } 100\text{°F}$ . Insulation shall be attached in strict accordance with the manufacturer's recommendations. All insulation shall be jacketed with 6 oz. canvas with fire retardant lagging.
- 6.1.1 For tanks, pumps, and equipment, Armacell engineered foam may be used. Total insulation thickness of 2".  $K=0.27 \text{ Btu in/hr ft}^2 \text{ °F @ } 75 \text{ °F}$ . Install per manufacturer's instructions utilizing black adhesive (low voc) with a minimum of 2" insulating tape.
- 6.1.2 Insulate pump volutes as part of the piping system as referenced in Part 5.

END OF SECTION 220700

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## SECTION 220800 - COMMISSIONING REQUIREMENTS

### PART 1 - GENERAL

#### 1.1 RELATED WORK

- 1.1.1 Division 1 – General
- 1.1.2 Division 23 - Mechanical
- 1.1.3 Division 26 – Electrical

#### 1.2 REFERENCES

- 1.2.1 Drawings and general provisions of contract, including general and supplementary conditions, general mechanical provisions and Division-1 Specification sections, apply to work of this section.
- 1.2.2 ASHRAE Guideline 1-1996
- 1.2.3 ASHRAE Guideline 0-2005
- 1.2.4 ACG Commissioning Guideline – 2005

#### 1.3 DESCRIPTION OF WORK

- 1.3.1 The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the mechanical systems have been installed in the prescribed manner, and operate within the performance guidelines set in the Basis of Design Documents (BOD). The CA shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The CA will be a member of the construction team, administrating and coordinating commissioning activities with the design team, general contractor, subcontractors, manufacturers and equipment suppliers.
- 1.3.2 The independent commissioning agent (CA) contracted directly with the owner for this project. This specification has been included for reference only to define contractors' responsibilities. Each contractor should review this procedure and include adequate time in their proposal.

### PART 2 - PRODUCTS

Not used.

### PART 3 - EXECUTION

#### 3.1 ROLES OF THE COMMISSIONING AGENCY

- 3.1.1 The primary point of responsibility is to inform the general contractor, the owner and design team on the status, integration, and performance of Plumbing systems within the facility.

- 3.1.2 The CA shall function as a catalyst and initiator to disseminate information and assist the design and construction teams in implementing completion of the construction process. This shall include system verification, functional performance testing, and conformance with the intended design of each system. Services include documenting construction observations, verification and functional performance testing, and documenting proper distribution of performance and operating information to the owner's O&M staff.
- 3.1.3 Assist the responsible parties to maintain a high-quality level of installation by meeting or exceeding prevailing standards and specifications.
- 3.1.4 The CA shall observe and coordinate testing as required to assure system performance meets the design intent.
- 3.1.5 The CA shall document the results of the performance testing directly and/or assure that the appropriate technicians document testing. The CA shall approve standard forms to be used by all parties for consistency of approach and type of information to be recorded.
- 3.1.6 The CA shall provide technical expertise to oversee and verify the correction of deficiencies found during the commissioning process.
- 3.1.7 The CA is to remain an independent party with specific knowledge of the project. The CA shall investigate the scope and extent of the problem and facilitate communication to determine responsibilities by delineating specifications. The CA shall monitor resolution for conformance with design intent and prevailing industry standards.
- 3.1.8 The CA shall document the date of acceptance as determined by the general contractor, owner and design team. System Verification Checklists and Functional Performance Test results may be used in determining the start of the warranty period for Plumbing systems and subsystems.
- 3.1.9 The CA will review operating and maintenance materials for Plumbing systems.
- 3.1.10 The CA will review phasing plans as provided by the CM relating to temporary use of Plumbing equipment, O&M considerations, warranty issues, impact of construction sequencing on occupied areas, and interruption of services from the existing equipment.
- 3.2 SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS  
Domestic Hot Water  
Automatic Flush Valves  
Water to Water Heat Pump Unit (Water Heater)
- 3.3 PLUMBING COMMISSIONING PLAN
- 3.3.1 Commissioning Team: The Commissioning Team (CT) shall consist of key parties involved in design, construction and testing of this facility. It is necessary for each agency to appoint team members that will have long-term commitments to this project. Switching team members during the project will reduce the ability of the CT to provide continuity and acceptable results to the building owner. Team members must maintain an ongoing supervisory position on this project. One team member shall be provided by each of the parties listed below:
- Program Manager (PrM)

- Facilities Management Division (FMD)
- Commissioning Agent (CA)
- Design Team (DT)
- General Contractor (GC)
- Mechanical Contractor (MC)
- Plumbing Contractor (PC)
- Controls Contractor (CC)
- Test and Balance Contractor (TABC)
- Electrical Contractor (EC)

### 3.3.2 Basis of Design Document

- The Basis of Design Document (BOD) represents a composite of design drawings, project specifications, submittals, change orders and industry standards that describe the systems of this facility. References to design intent will be taken from these contract documents. The BOD is an evolving manuscript maintained by the design professional to track and incorporate design alterations that occur throughout the construction process. Any industry standards used for this project will be specifically noted when referenced.
- The CA will review the BOD documents for adequate commissioning provisions, functional performance, optimization of performance, accessibility, TAB provisions, and O&M considerations.

### 3.3.3 Commissioning Meetings: Commissioning meetings will be held in conjunction with progress meetings as necessary. The CA will be on site for the CX meetings. Commissioning meetings will be used to address any problems that alter the design intent or affect the commissioning process. These meetings provide an open forum for exchange of ideas between contractors, vendors, designers, users and owners.

### 3.3.4 Resolution Tracking Forms (RTF)

- The use of Resolution Tracking Forms is a method employed by the CA to monitor and record problems, their causes, and solutions. The use of these lists promotes communication between the installing contractors, design team, commissioning agent, and owner, in order to expedite their resolution in a timely manner.
- The CA will regularly submit RTF's to the CT in order to document and resolve deficiencies as quickly as possible. The frequency of RTF submission will be adjusted as project conditions dictate.

### 3.3.5 System Verification Checklists (SVC) / Manufacturers' Checklists

- The MC/PC shall provide SVC's based on the manufacturers start-up procedures. These tests will be created for systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS*. Draft copies will be submitted to the CT for review and comment prior to placement on the job site. A master copy of the SVC's will be bound in a three-ring binder and placed on the job site for use by the installing contractors. No system will be started until the appropriate SVC's have been completed.
- The CA will review the SVC for each piece of equipment prior to start-up. Equipment will be released for start-up only after these checklists have been completed by the installing contractor and reviewed by the CA.
- The equipment manufacturers' checklists must also be reviewed by the CA prior to start-up. These lists must be completed by the installing contractor, and reviewed by the CA before start-up can commence.

### 3.3.6 Start-Up

- Start-up of major Plumbing systems will be witnessed the CA. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate SVC's have been completed. No system will be started until the Manufacturer's checklists have been completed. Start-up will be performed according to the Manufacturer's recommended procedures. The CA will visit the site to review completeness of installation in conjunction with progress meetings prior to starting Plumbing equipment.
- CT members involved in installation, fabrication, manufacture, control, or design of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the BoD.

### 3.3.7 Functional Performance Tests (FPT)

- The CA will write FPT's based on the BoD. These tests will be created for systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS* above.
- Each major system will be tested. A random sample of each subsystem will be tested. This will be coordinated and witnessed by the CA and the owner's maintenance staff. Witnessing the FPT's will serve as a compliment to the O&M Training. No FPT's will be performed until the system and related subsystems have been started, the TAB report has been submitted and reviewed, and the completion of the control system has been documented through point-to-point checklists and other documentation.
- The Functional Performance Tests shall include Plumbing and related equipment.
  - Hot water system will be tested.
  - Water to Water Heat Pump Units (Water Heaters) will be tested under relevant operating conditions.
  - DDC control systems will be tested as necessary.
- Deferred Testing
  - If tests cannot be completed because of a deficiency outside the scope of the responsible contractor, the deficiencies shall be documented and reported to the Owner. Deficiencies shall be resolved and corrected by the appropriate parties and test rescheduled.
  - Off-season mode testing will be implemented as necessary to assure conformance with the BoD. Installing contractors will be expected to participate as required by the project specifications.
- Rescheduled Functional Performance Test
  - During Functional Performance Testing period, it is assumed that the contractors will be complete with all checklists when the commissioning agents travel to site. If the work is not ready for commissioning when the commissioning personnel are on site, contractor shall reimburse the owner for all additional cost the owner incurs as a result of the contractor's failure to be complete and/or to provide operating compliant systems for commissioning. Additional costs include but are not limited to additional fees charged by the architect, engineer, general contractor and commissioning agent.
  - If the contractor has deficiencies that cannot be corrected at the time of the test, that part of the sequence will be retested at a later date. If the deficiency does not pass during the retest, the contractor will be billed for the commissioning personnel's return trip.

### 3.3.8 Building Turn-Over / Owner Orientation / User Training

- The CA will assist contractors prepare, coordinate and review O&M manuals, working closely with each contractor to achieve specificity and completeness.
- The CA will review as-built drawings, working closely with each contractor to achieve specificity and completeness.
- Owner training will be coordinated with the assistance of the CA. The training will be provided by the installing contractor, or manufacturer's representative, and witnessed by the CA. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The CA will visit the site during the Turn-Over and Training period to assure that any on-going Plumbing related problems are being addressed and corrected in a timely and efficient manner.
- The CA will assist the owner/user with warranty issues.
- The CA will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.

## 3.4 RESPONSIBILITIES OF TEAM MEMBERS

### 3.4.1 General Contractor (GC)

- Include commissioning requirements in the mechanical, electrical, and controls contracts, as well as other subcontracts, to assure full cooperation of all parties in the Plumbing commissioning process.
- Assure acceptable representation, with the means and authority to prepare and coordinate execution of the mechanical commissioning program as described in the contract documents.
- Assure that the CA shall receive a copy of all construction documents, addenda, change orders and appropriate approved submittals and shop drawings for review and use in development of the commissioning plan.
- Coordinate inclusion of commissioning activities in the construction schedule.
- Facilitate resolution of deficiencies identified by observation or performance testing.
- Assist the CA in monitoring the duct leakage testing.

### 3.4.2 Plumbing Contractor (PC)

- Include cost for commissioning requirements in the contract price.
- Attend commissioning meetings scheduled by the CA.
- Verify proper installation and performance of all plumbing services provided.
- Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of equipment.
- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Provide an electrical system technician to assist during verification and performance testing.
- Participate in the Functional Performance Tests as required to achieve design intent.
- Participate in the off-season mode testing as required to achieve design intent.
- Participate in O&M Training as required by project specifications.

END OF SECTION 220800

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## SECTION 222100 - EXCAVATION, TRENCHING, BACKFILLING AND GRADING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall include all excavating, filling, grading, and related items required to complete their work as shown on the drawings and specified herein or as required to complete, connect and place all mechanical systems in satisfactory operation.
- 1.3 Unless otherwise shown or required, provide separate trenches for sewers, water lines and other underground raceways, with a minimum of 10 feet measured from outside diameter between pipes. In locations, such as close to buildings where separate trenches for sewers and water lines are impractical, lay the water pipe on a solid shelf at least 2'-0" above the top of the sewer and 2'-0" to the side.
- 1.4 Water lines crossing under sewer lines, or crossing less than 2 feet above sewer lines, must be concrete encased for a distance not less than 5 feet on either side of the point of crossover.

### PART 2 – EARTHWORK CLASSIFICATION:

- 2.1 Without regard to the materials encountered, all excavation and materials excavated shall be unclassified. Materials to be excavated shall be unclassified, and shall include earth, rock, concrete or any other obstructions encountered in excavation and/or trenching to install underground utility pipes or other equipment.
- 2.2 Include all costs for rock removal, including mass rock and trench rock in the bids. No adjustment in the contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in the excavating. The Contractor shall be responsible for the removal of all materials encountered as required for the installation of the work.
- 2.3 It shall be distinctly understood that references to rock, earth, topsoil or any other excavated or non-excavated material or other material on the construction plans, cross section, contract documents, technical specification or provisions, whether in numbers, words, letters, lines or graphically shown, is solely for information for the Engineer and Owner. This information shall not be taken as an indication of the classification of the material to be excavated, bored or removed by any method, including drilling and blasting, or materials not removed. This information shall not be taken as to the quantity of either rock, earth, topsoil, or any other material involved, or the quality of the material such as hardness, wetness, workability or suitability of the material either during excavation and construction or as a material to be reused during construction.
- 2.4 The Contractor shall draw their own conclusions as to the surface and sub-surface conditions to be encountered during construction of this project. The Engineer and Owner does not give any guarantee or warranty as to the accuracy of the data shown and no claim will be considered for additional compensation when the materials encountered are not in accord with the information shown.

- 2.5 Refer to Specification Division EARTHWORK located in the Site Work portions of the Specifications and Civil Drawings for additional information. Also refer to the GEOTECHNICAL report included in the Front End of the Specifications.

PART 3 – BENCH MARKS AND MONUMENTS:

- 3.1 Maintain carefully all bench marks, monuments and other reference points. If disturbed or destroyed, replace as directed.

PART 4 – EXCAVATION:

- 4.1 Excavate trenches of sufficient width for proper installation of the work. Excavate to 6" below the bottom of new pipes for installation of compacted grillage.
- 4.2 Sheet and brace trenches as necessary to protect workers and adjacent structures. Comply with local regulations or, in the absence thereof, with the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc., and current OSHA Standards. Do not remove sheeting until trench is backfilled sufficiently to protect pipe and prevent injurious caving. Where removal of sheeting and/or bracing is hazardous, leave in place. Cut off such sheeting not to be removed at least 3 feet below finished grade.
- 4.3 Rules and regulations governing the respective utilities shall be observed in executing all work under this Division. Active utilities discovered in the course of excavation shall be protected or relocated in accordance with written instructions from the Engineer. Inactive and abandoned utilities encountered in trenching operations shall be removed and abandoned with ends plugged or capped in accord with current codes and safe practice. If in doubt, contact Engineer.
- 4.4 Machine excavation shall not be allowed within ten (10) feet of existing electric lines, natural gas lines or other lines carrying combustible materials. Use only hand tools.
- 4.5 The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted unless authorized in writing by the Engineer. Any damage to existing structures, exterior services, or rock intended for bearing, shall be corrected at the responsible Contractor's expense.
- 4.6 Perform final grading of trench bottoms by hand tools; carry machine excavation only to such depth that soil bearing for pipes and raceways will not be disturbed. Grade the bottom of trenches evenly to insure uniform bearing for all piping and raceways. Cut bell holes as necessary for joints and jointmaking. Except as hereinafter specified, bottom of trenches for bell and spigot pipe, flanged pipe, etc. shall be shaped to the lower quadrant of pipe with additional excavation for bell or flange. Piping installed where it rests on bell or flange and/or is supported with blocks or wedges will not be accepted.
- 4.7 Keep trenches free from water while construction therein is in progress. Under no circumstances lay pipe or appurtenances in water. Pump or bail water from bell holes to permit proper joining of pipe. Any dewatering from this Contractor's trenches which is required during construction, shall be included in this Contract.

- 4.8 In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, utility lines, large trees to remain, etc. The Contractors shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage or any other damage incurred in the course of excavation shall be at the responsible Contractor's expense.
- 4.9 Use surveyor's level to establish elevations and grades.
- 4.10 Machine excavation shall be held a sufficient distance from foundations and footings to insure no damage to same. Contractors shall accept full responsibility and pay for repairs and/or replacement of structural members, footings, etc.
- 4.11 The Contractor shall accept the site as it is and remove all trash, rubbish and material from the site prior to starting excavation work.
- 4.12 The Contractor shall provide and maintain barricades and temporary bridges around excavations as required for safety. Temporary bridges shall be provided where excavations cross paved areas and walks. The Contractor shall maintain these bridges in a safe and passable condition for all traffic until removal. Refer to OSHA Standards for such installations and comply with same in all details.
- 4.13 Pay particular attention to existing utilities and lines to avoid damage. The locations of existing lines which are indicated on the plans were taken unconfirmed from drawings prepared for previous construction and locations are approximate only. Also, certain water, gas, electric, storm and sanitary sewer lines and other underground appurtenances, active or abandoned, may not appear on the drawings. It shall be each Contractor's responsibility to ascertain the location of all lines and excavate with caution in their area.
- 4.14 Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor's expense.

#### PART 5 – BACKFILL, COMPACTION AND SURFACE REPAIR:

- 5.1 Backfilling for Mechanical Work shall include all trenches, manhole pits, storage tank pits, and/or any other earth and/or rock openings which are excavated under this Contract. Backfilling shall be carefully performed and the surface restored to its original level to receive new finish. Wherever trenches and earth openings have not been properly filled and/or settlement occurs, they shall be re-excavated, re-filled and properly compacted, smoothed off and finally made to conform to the level of the original ground surface.
- 5.2 All trenches shall be backfilled with 6" of manufactured sand or #8 crushed stone after finished excavation. Install the new pipe on the compacted fill material. Install tracer wire on pipe. Apply any special coatings to the pipe. Also perform all required pressure tests and check the grade of the pipe to ensure that it is correct and free of swags, bows or bends. Once coatings and testing are complete, backfill the pipe bed to 12" above the top of the pipe with specified compacted fill material. Backfill the remainder of the trench with earth (rock and debris free) tamped at 6" intervals. Water settling of backfill is permitted only as an aid to mechanical compacting.

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- 5.3 Backfill and compact beneath areas to be seeded or sodded within six (6) inches of finished grade. The remaining six (6) inches shall be backfilled with clean top soil.
- 5.4 Backfill and compact beneath paved areas, walks, etc. shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill or unstable soil.
- 5.5 Wherever, in the opinion of the Engineer, the soil at or below the requisite pipe grade is unsuitable for supporting piping, special support shall be provided as directed by the Engineer.
- 5.6 Unsuitable material and surplus excavated material not required for backfill shall be removed from the site. The location of dump and length of haul shall be the affected Contractor's responsibility.
- 5.7 Provide and place any additional fill material from off the site as may be required for backfill. Fill obtained from off site shall be of kind and quality as specified for backfill and the source approved by the Engineer and shall be brought to the site by the Contractor requiring the fill.
- 5.8 If not specified or indicated elsewhere in the Contract Documents to be performed by Others, the Contractor shall lay new sod over their excavation work for existing disturbed grassy areas. Level, with adjacent surface, compact and water in accord with sound sodding practice.
- 5.9 Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated as follows.
- 5.10 At a minimum, fill in grass areas shall be compacted to 90% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.
- 5.11 At a minimum, fill in concrete or asphalt area shall be compacted to 98% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.
- 5.12 Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.
- 5.13 Grading Outside Building Lines:
- 5.13.1 All materials used for backfill around structures shall be of a quality acceptable to the Engineer and shall be free from large or frozen lumps, large rocks, wood, and other extraneous material. All spaces excavated and not occupied by footings, foundations, walls or other permanent work shall be refilled with earth up to the surface of the surrounding ground, unless otherwise specified, with sufficient allowance for settlement.
- 5.13.2 In making the fills and terraces around the structures, the fill shall be placed in layers not exceeding 8 inches in depth and shall be kept smooth as the work progresses. Each layer of the

fill shall be compacted. Sections of the fill immediately adjacent to buildings or structures shall be thoroughly compacted by means of mechanical tamping or hand tamping as may be required by the conditions encountered. All fills shall be placed so as to load structure symmetrically.

- 5.13.3 As set out hereinbefore, rough grading shall be held below finished grade and then the topsoil which has been stockpiled shall be evenly spread over the surface. The grading shall be brought to the levels as specified. Final dressing shall be accomplished by hand work or machine work, or a combination of these methods as may be necessary to produce a uniform and smooth finish to all parts of the regrade. The surface shall be free from clods greater than one inch in diameter. Excavated rock (1" and smaller) may be placed in the fills, but is shall be thoroughly covered. Rock placed in fills shall not be closer than 24 inches from finished grade. Refer to Specification Division EARTHWORK.
- 5.14 Maintenance Settling: Where settling is measurable or observable at excavated areas during Project Warranty Period, remove surface (pavement, concrete or any other surface or finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration.
- 5.15 Disposal of Excess Non-organic Soil and Rock: Any excess excavated waste material shall become the property of the Contractor and shall be disposed of by the Contractor off site at no additional cost to the Owner.
- 5.16 Unless otherwise directed by the Owner during construction, excess topsoil and subsoil suitable for fill shall be disposed of by the Contractor off site at no additional cost to the Owner.

#### PART 6 – MINIMUM DEPTHS OF BURY TO TOP OF PIPE:

- 6.1 In the absence of other indication, the following shall be the minimum depth of bury to top of pipe of exterior utility lines. Check drawings for variations.
- |       |                            |                              |
|-------|----------------------------|------------------------------|
| 6.1.1 | Storm Lines                | 24 inches below final grade. |
| 6.1.2 | Sanitary Lines             | 36 inches below final grade. |
| 6.1.3 | All Other Lines Not Listed | 36 inches below final grade. |
- 6.2 All exterior lines shall have a minimum earth cover of thirty six (36) inches to top of pipe, unless otherwise indicated.

END OF SECTION 222100

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## SECTION 222200 – PLUMBING PIPING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 Each Contractor's attention is also directed to Specification Section HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT.
- 1.3 Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified.
- 1.4 Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.
- 1.5 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.
- 1.6 The piping indicated shall be installed complete and shall be of the size indicated. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineer. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.
- 1.7 All piping shall be installed straight and true, parallel or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers and other building openings.
- 1.8 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants. Reference 230529 for additional piping support requirements.
- 1.9 Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation. Refer to Specification Section PLUMBING INSULATION, EQUIPMENT, AND PIPING.
- 1.10 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.

- 1.11 In buildings with steel joists, support piping with standard pipe hangers with C-clamp connection to main structural members (not perkins), use angle steel cross pieces between main structural members where required to provide rigid support.
- 1.12 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.
- 1.13 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.
- 1.14 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to ensure that no foreign matter is lodged therein.
- 1.15 All hot and cold-water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.
- 1.16 Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing. If in doubt, consult Engineer.
- 1.17 Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.
- 1.18 Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.
- 1.19 Dielectric unions shall be provided at all connections of dissimilar materials.
- 1.20 Nipples shall be of the same material, composition and weight classification as pipe with which installed.
- 1.21 Apply approved pipe dope for service intended to all male threaded joints. The dope shall be listed for intended use.
- 1.22 Eccentric reducers shall be used where required to permit proper drainage and venting of pipe lines; bushings shall not be permitted.
- 1.23 Installation of pipe shall be in such a manner as to provide complete drainage of the system, whether detailed or not on plans. Drain valves shall be provided at all drainage points on pipes.



- Drain valves shall be ½" size ball valves with ¾" hose thread end and vacuum breaker. Label each drain valve.
- 1.24 Where plastic piping penetrates a fire rated assembly, it shall be replaced with a threaded metal adapter and metal pipe or whatever means necessary to maintain the separation rating in accordance with local plumbing and fire codes.
- 1.25 All increases in vent size at roof shall be by means of service weight cast iron increasers.
- 1.26 Installation of pipe shall be in such a manner as to provide complete drainage of the system toward the source. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be ½" size ball valves with ¾" hose thread end and vacuum breaker. Label each drain valve.
- 1.27 Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted.
- 1.28 Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineer.
- 1.29 When running any type of pipe below a footing, perpendicular to the footing, the area underneath the footing and in the zone of influence shall be backfilled with concrete. The zone of influence is the area within a 45 degree angle projecting down from the top edge of footing on all sides of the footing.
- 1.30 When running any type of pipe below a footing, parallel to the footing, the area underneath the zone of influence shall be backfilled with 4" of crushed stone or sand bedding under the pipe. Each pipe section shall be anchored into unexcavated earth on both ends with deadman anchor system. The remainder of the trench in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45 degree angle projecting down from the top edge of the footing on all sides of the footing.
- 1.31 Piping for all drainage systems shall be installed to permit flow, trapping, and venting in accord with current codes and best practice.
- 1.32 The domestic hot, recirculating and cold-water piping system shall be sterilized in strict accord with requirements of the Department of Health Codes, Rules and Regulations for the State in which the work is being accomplished.
- 1.33 When connecting to the hydronic water system (chilled / hot, geothermal, etc.), the Contractor shall include cost to drain the piping system and refill with water/closed loop chemicals. If the building is occupied, and the drain down will affect services to these occupied areas, then the systems shall be drained and refilled over a weekend at a time acceptable to the Owner. Refer to Specification Section HVAC WATER TREATMENT, CLEANING, FILLING, AND PURGING.

## PART 2 – UNIONS, FLANGES AND WELDED TEES:

- 2.1 Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.
- 2.2 Dielectric insulating unions or couplings shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.
- 2.3 Tee connections for welded pipe shall be assembled with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is  $\frac{2}{3}$  the run size or smaller.
- 2.4 Weld-o-let, thread-o-let and T-drill branch connections are acceptable.

## PART 3 – SPECIFICATIONS STANDARDS:

- 3.1 All piping and material shall be new, made in the United States and shall conform to the following minimum applicable standards:
  - Steel pipe; Schedule 40; ASTM A-53.
  - Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.
  - Cast iron soil pipe; ASA A-40.1 and CS 188-59.
  - Cast iron drainage fittings; ASA B16.12.
  - Cast iron screwed fittings; ASA B16.4.
  - Welding fittings; ASA B16.9.
  - Cast brass and wrought copper fittings; ASA B16.18.
  - Cast brass drainage fittings; ASA B16.23.
  - PVC pipe; Schedule 40; ASTM D-1785.

## PART 4 – PIPE TESTING:

- 4.1 Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.
- 4.2 Water piping systems shall be subjected to a hydrostatic test of 150 psi. The system shall be proven tight after a twenty-four (24) hour test.
- 4.3 The house drain line, interior storm sewers, interior rain water conductors, and all soil, waste and vent piping shall be subjected to a hydrostatic test of not less than a 10-foot head or an air test of not less than 5 psi and shall hold for 15 minutes.

- 4.4 Exterior sewer lines to the termination point outside the building shall be subject to a ten-foot hydrostatic test or an approved smoke test. These lines shall be subjected to a second test after 2 feet of backfill has been properly installed.
- 4.5 After fixtures have been installed, the entire plumbing system, exclusive of the house sewer, shall be subjected to an air pressure test equivalent to one inch water column and proven tight. The Contractor responsible shall furnish and install all of the test tees required, including those for isolating any portion of the system for tests.
- 4.6 The Contractor shall perform all additional tests that may be required by the Department of Health or other governing agency.
- 4.7 Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

PART 5 – PITCH OF PIPING:

- 5.1 All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:
- 5.2 INTERIOR SOIL, WASTE AND VENT PIPING: ¼" per foot in direction of flow where possible but in no case less than 1/8" per foot.
- 5.3 SITE SANITARY LINES: Not less than one (1) % fall in direction of flow and no greater than indicated.
- 5.4 ALL OTHER LINES: Provide ample pitch to a low point to allow 100 percent drainage of the system.

PART 6 – EXTERIOR APPLICATIONS (SITE WORK):

- 6.1 SITE SANITARY SEWER: Refer to the Civil Plans and Specifications.
- 6.2 SITE WATER: Refer to the Civil Plans and Specifications.
- 6.3 SITE FIRE PROTECTION: Refer to the Civil Plans and Specifications.

PART 7 – PLUMBING PIPING APPLICATIONS:

- 7.1 SOIL, WASTE AND VENT PIPING (BELOW SLAB):
  - 7.1.1 Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Plumbing Code. PVC pipe shall not be installed where waste water applications exceed 140 deg F. Pipe and fittings shall be manufactured from PVC compound with a cell class of 12454 per ASTM D 1784 and conform with National Sanitation Foundation (NSF) standard 14. Pipe shall be iron pipe size (IPS) conforming to ASTM D 1785 and ASTM D

2665. Injection molded fittings shall conform to ASTM D 2665. Fabricated fittings shall conform to ASTM F 1866.

7.1.2 Piping below slab shall be a minimum of 2" in size.

7.2 GREASE, WASTE AND VENT PIPING (BELOW SLAB):

7.2.1 Hubless Cast Iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A 888 and CISPI Standard 301. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute ® and listed by NSF® International. Heavy Duty Couplings shall conform to CISPI Standard 310 and be certified by NSF® International. Heavy Duty couplings shall conform to ASTM C 1540 and shall be used. Gaskets shall conform to ASTM C 564. All pipe and fittings to be produced by a single manufacturer and are to be installed in accordance with manufacturer's recommendations and applicable code requirements. Couplings shall be installed in accordance with the manufacturer's band tightening sequence and torque recommendations. Tighten bands with a properly calibrated torque limiting device. The system shall be hydrostatically tested after installation to 10 ft. of head (4.3 psi maximum).

7.2.2 Piping below slab shall be a minimum of 2" in size.

7.3 SOIL, WASTE AND VENT PIPING (ABOVE SLAB):

7.3.1 Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Plumbing Code. PVC pipe shall not be installed where waste water applications exceed 140 deg F. Pipe and fittings shall be manufactured from PVC compound with a cell class of 12454 per ASTM D 1784 and conform with National Sanitation Foundation (NSF) standard 14. Pipe shall be iron pipe size (IPS) conforming to ASTM D 1785 and ASTM D 2665. Injection molded fittings shall conform to ASTM D 2665. Fabricated fittings shall conform to ASTM F 1866.

7.4 DOMESTIC COLD, HOT AND RECIRCULATING HOT WATER PIPING (ABOVE SLAB):

7.4.1 Type "L" hard copper tubing with wrought copper fittings (ANSI B16.22) with lead free solder equivalent in performance to 95/5. (Maximum lead content of solder and flux is 2%). ASTM B88

7.5 DOMESTIC COLD, HOT AND RECIRCULATING HOT WATER PIPING (BELOW SLAB): Type "K" hard or soft copper tubing with wrought copper fittings and brazed joints. There shall be no joints beneath slabs.

7.6 WATER HEATER RELIEF LINE: Type "M" copper tubing with sweat fittings and 95/5 solder

END OF SECTION 222200

## SECTION 223000 - PLUMBING EQUIPMENT

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
- 1.3 The Contractor shall provide in complete working order the following plumbing equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.
- 1.4 All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for special warranty requirements.
- 1.5 Review the Specification Section – REQUIRED SHOP DRAWINGS, ETC., and provide all documentations called for therein.
- 1.6 All plumbing equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.
- 1.7 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.
- 1.8 Determine from the Bid Documents the date of completion of this project and insure that equipment delivery schedules can be met so as to allow this completion date to be met.
- 1.9 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section - ELECTRIC MOTORS, ETC. for additional requirements. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.
- 1.10 Review the Specification Section - CONTROLS to determine automatic controls requirements through the Building Automation System.

- 1.11 Review the Specification Section – TESTING, BALANCING, LUBRICATION AND ADJUSTMENTS.

PART 2 - GEOTHERMAL WATER-TO-WATER HEAT PUMP UNITS:

- 2.1 MANUFACTURERS: Water Furnace (Basis of Design), Lochinvar. Other manufacturers require pre-approval and will only be accepted via Procurement Substitution Requests or Substitution for Cause.
- 2.2 System Description: Heat Pump shall incorporate Scroll-type compressors and can consist of multiple modules. Each refrigerant circuit shall consist of an individual compressor, common dual circuited condenser, dual circuited evaporator, thermal expansion valves, reversing valve, and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-circuit heat pump must be able to produce chilled water even in the event of a failure of one or more refrigerant circuits. Circuits shall not contain more than 12 lb. of R-134a refrigerant.
- 2.3 Equipment shall be specifically designed for applications within conditioned interior areas. Capacities shall be rated in accordance with ARI for geothermal applications. Equipment shall be ETL or CSA approved. All equipment shall have decals and labels to aid in servicing and indicate caution areas.
- 2.4 Equipment shall be completely factory assembled and tested, piped, internally wired and fully charged with Refrigerant R-134a. Threaded female water inlet and outlet connections, threaded female condensate connection and all safety controls shall be furnished and factory installed.
- 2.5 A terminal block with screw terminals shall be provided for control wiring. An energy management relay to allow unit control by an external source shall be factory installed.
- 2.6 Refer to Specification Section 220100 - COMMON WORK RESULTS FOR PLUMBING for warranty requirements.
- 2.7 Operating Conditions:
- Provide water-to-water heat pump with the capacity as scheduled on drawings at job site elevation operating with 45°F to 120°F geothermal water supply temperature.
  - Heat Pump shall be designed to operate using R-134a Refrigerant.
  - Heat Pump shall be designed for parallel evaporator water flow.
  - The liquid to be heated and cooled will be water containing corrosion inhibitors.
  - Heat Pump shall be designed to operate using 3 phase, 60 Hz electrical power supply as scheduled on the drawings.
- 2.8 General:
- Heat Pump Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236.
  - Modules shall ship wired and charged with refrigerant. All modules shall be factory run tested prior to shipment on an AHRI certified or 3<sup>rd</sup> party verified test stand.

- Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module.
- 2.9 Water Mains: Each module shall include supply and return mains for both load and source-sink water. Water Mains shall be installed such that they are beneath any power or control wiring to insure for safe operation in the event of condensation or minor piping leaks.
- 2.10 Heat Exchangers: Each load and source-sink heat exchanger shall be brazed plate heat exchangers constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig refrigerant side working pressure and 360 psig water side working pressure. Heat exchangers shall be mounted below the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up.
- 2.11 Compressor: Each module shall contain two hermetic scroll compressors independently circuited and with internal spring isolation mounted to the module with rubber-in-shear isolators. Each system also includes high discharge pressure and low suction pressure manual reset safety cut-outs.
- 2.12 Electrical:
- The unit control box shall contain all necessary devices to allow heating and cooling operation to occur from a building DDC control system utilizing sensors and control components. These devices shall be as follows:
    - 75 VA transformer
    - A low voltage terminal strip is located inside the control panel behind the service access panel. This terminal strip may be used for low voltage control connections.
  - Units shall include integral disconnect.
- 2.13 Central Control System.
- Scheduling of the various compressors shall be performed by a microprocessor based control system (Master Controller). A new lead compressor is selected every 24 hours to assure even distribution of compressor run time.
  - The heat pump unit (water heating) shall monitor the storage tanks and operate as required to maintain the 140 F domestic hot water tank temperature.
  - The Master Controller shall monitor and report the following on each refrigeration system:
    - Discharge Pressure Fault
    - Suction Pressure Fault
    - Compressor Winding Temperature
    - Suction Temperature
    - Load Leaving Water Temp.
    - Source-Sink Leaving Water Temp.
    - Domestic hot water supply temperature (tank).
  - The Master Controller shall be powered by a single point power connection and shall monitor and report the following system parameters:
    - Load Water Entering and Leaving Temperature
    - Source-Sink Water Entering and Leaving Temperature
    - Load Water and Source-Sink Water Flow

- An out of tolerance indication from these controls or sensors shall cause a “fault” indication at the Master Controller and shutdown of that compressor with the transfer of load requirements to the next available compressor. In the case of a System Fault the entire heat pump will be shut down. When a fault occurs, the Master Controller shall record conditions at the time of the fault and store the data for recall. This information shall be capable of being recalled through the keypad of the Master Controller and displayed on the Master Controller’s 2 line by 40 character back-lit LCD. A history of faults shall be maintained including date and time of day of each fault (up to the last 20 occurrences).
  - Individual monitoring of leaving water temperatures from each refrigeration system shall be programmed to protect against heat exchanger freeze-up and over temperature conditions.
  - The control system shall monitor entering and leaving water temperatures to determine system load and select the number of compressor circuits required to operate. Response times and set points shall be adjustable. The system shall provide for variable time between compressor sequencing and temperature sensing, so as to optimize the heat pump performance to different heating hot water loads.
  - The heat pump mode (heating only) shall be selected by an external dry contact interlock to the Master Controller.
- 2.13.1 Heat pump shall have a single point power connection and external inputs and outputs to be compatible with the building management system.
- 2.13.2 Each inlet water header shall incorporate a built in 30-mesh (maximum) in-line strainer system to prevent heat exchanger fouling and accommodate 100% flow filtration with a minimum surface area of 475 sq inches per module.
- 2.13.3 Single Point Power: Chiller shall be equipped with a pre-engineered genuine buss bar electrical system for single point power rated at a 5,000 amp SCCR. Where the equipment size exceeds the amp rating of the buss bar, multiple power connections may be applied. Pre-engineered system shall also incorporate individual module isolation circuit breakers for full redundancy and ability of a module to be taken off-line for repair while the rest of the modules continue to operate. Individual power feeds to each module shall be unacceptable.
- 2.14 SAFETIES, CONTROLS AND OPERATION:
- Heat pump safety controls system shall be provided with the unit (minimum) as follows:
    - Low refrigerant pressure
    - Loss of flow through the source/sink heat exchanger
    - Loss of flow through the load heat exchanger
    - High refrigerant pressure
    - High compressor motor temperature
    - Low suction gas temperature
    - Low leaving water temperature
- 2.14.1 Failure of heat pump to start or heat pump shutdown due to any of the above safety cutouts shall be annunciated by display of the appropriate diagnostic description at the unit control panel. This annunciation will be in plain English. Alphanumeric codes shall be unacceptable.
- 2.14.2 The heat pump shall be furnished with a Master Controller as an integral portion of the heat pump control circuitry to provide the following functions:



- Provide automatic heat pump shutdown during periods when the load level decreases below the normal operating requirements of the heat pump. Upon an increase in load, the heat pump shall automatically restart.
- Provisions for connection to automatically enable the heat pump from a remote energy management system.
- The control panel shall provide alphanumeric display showing all system parameters in the English language with numeric data in English units.

2.14.3 Normal Heat pump Operation:

- When heat pump is enabled, the factory supplied Master Controller modulates the heat pump capacity from minimum to maximum as required by heating hot water load.
- The heat pump control system shall respond to Entering Water Temperature and will have an integral reset based on entering water temperature to provide for efficient operation at part-load conditions.

2.14.4 Power Phase Monitor:

- Provide a Power Phase Monitor on the incoming power supply to the heat pump. This device shall prevent the heat pump from operating during periods when the incoming power is unsuitable for proper operation.
- The Power Phase Monitor shall provide protection against the following conditions:
  - Low Voltage (Brown-Out)
  - Phase Rotation
  - Loss of Phase
  - Phase Imbalance

2.15 HOSE KIT & PIPING PACKAGE: Hose kits and piping package shall be as scheduled on the drawings. Two piece hose kits shall be provided for hose kits that are 2" and larger in size. Hose kits shall be the pipe runout size, not heat pump connection sizes. No exceptions! Hose kit and piping package configuration shall match the Geothermal Heat Pumps specifications. Refer to HOSE KIT Specification Section for additional requirements.

2.16 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section GENERAL PROVISIONS - MECHANICAL. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements.

2.17 Provide eight (8) hours of onsite training for this system. All training to occur after building completion. System shall function properly and O&M staff shall be able to operate the system prior to turnover.

END OF SECTION

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## SECTION 223123 - PUMPS

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard. Motors to be high efficiency type. Refer to Specification Section – ELECTRIC MOTORS, ETC.
- 1.3 Shop drawings shall be submitted as required and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.
- 1.4 Pumps shall be factory tested, cleaned and painted prior to shipment. Size, type, capacity and electrical characteristics are listed in the pump schedule.
- 1.5 Insofar as possible, all pumps shall be by the same manufacturer.

### PART 2 – PERMANENTLY LUBRICATED INLINE PUMPS:

- 2.1 Permanently Lubricated Inline Pumps shall be as scheduled and manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.
- 2.2 The pumps shall be of the horizontal permanently lubricated type, specifically designed for quiet operation. Suitable for 225 degrees F operation at 150 PSIG working pressure.
- 2.3 The pumps shall have a solid high-strength alloy steel shaft supported by XL11 permanently lubricated sealed precision bearings. Bearings are to be permanently oil lubricated. Pump shaft shall connect to a non-metallic noryl impeller.
- 2.4 Pump shall have integral stainless steel face plate and double sided stainless steel neck rings for increased life and seasonal start-up capabilities.
- 2.5 Pump volute shall be of cast bronze. The connection style on bronze pumps shall be flanged with isolation valves.
- 2.6 The motor shall be isolated from circulating fluid through use of a carbon/silicone seal attached on a stainless steel shaft sleeve.
- 2.7 Motors shall be of an Open Drip-Proof design and shall be non-overloading at any point on the pump curve. Motors shall be UL and CSA listed.

- 2.8 Pump shall be of a maintenance free design and be capable of operating in variable speed (varying voltage) applications.

END OF SECTION 223123

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## SECTION 224000 - PLUMBING FIXTURES, FITTINGS AND TRIM

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS – PLUMBING and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall provide all fixtures complete with trim required and connect in a manner conforming to the State Plumbing Code.
- 1.3 The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of the rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.
- 1.4 All fixtures and trim shall be new. All fixtures and trim shall be installed as recommended by the manufacturer. All fixtures shall be set level and true and shall be grouted into finished walls, floors, etc. in a neat and workmanlike manner with an approved waterproof non-yellowing grout for such service. All fixtures and trim shall be installed in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost. Pay particular attention to flush valves and bracket concealed portion to building structure during rough-in. Loose, shaky flush valves, lavatories, etc. shall not be acceptable.
- 1.5 Handicapped accessible fixtures shall be mounted as recommended by the Building Code and ADA. Special Note for Handicap Grab Rails: Coordinate top of shower valves, flush valves, flush tank, etc., with location of grab rails as shown on the architectural plans. The Contractor shall install all items to allow for installation, removal and service without removal of the grab bar.
- 1.6 Fixture seats shall be Church model 2155CTJ, elongated open front less cover w/ JUST-LIFT, STA-TITE check hinge and DuraGuard Antimicrobial Agent, or approved equal.
- 1.7 All exposed piping, stops, traps, tailpieces, etc. shall be code approved chrome plated brass unless otherwise indicated or specified. Where acid resistant piping is indicated on the drawing or the specifications, all piping and ancillary components from the sink/lavatory to dilution basin shall be acid resistant as specified and required by code.
- 1.8 Water supplies shall connect through walls with stops and chrome plated escutcheons with set screws. In general, furnish drinking fountains, wall-hung lavatories and hose bibbs with manual loose key stop valves. For all other fixtures, furnish with manual permanent-key stop valves (i.e. sinks in casework, etc.). When in doubt, contact Engineer prior to installation.
- 1.9 Coordinate all stainless steel sinks with architectural casework shop drawings for appropriate fit. Do not order sinks until this has been coordinated. Change Orders will be immediately rejected for lack of coordination during construction.
- 1.10 Test for appropriate operation at least twice, ALL fixtures and trim including hands-free trim. Open all faucets and allow to run for fifteen (15) minutes, then remove all faucet aerators and thoroughly clean until smooth flow is obtained. Test by operation at least twice, adequate flow of

water at flush valves including appropriate adjustment of hands-free devices, faucets including appropriate adjustment of hands-free devices, hose bibbs, fixture drains, shower heads, etc.

- 1.11 Remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from plumbing fixtures and thoroughly clean same.
- 1.12 ACCEPTABLE MANUFACTURERS: Subject to compliance with requirement's manufacturers offering plumbing fixtures and trim which may be incorporated in the work include only the following:
  - A. Plumbing Fixtures: American Standard, Kohler, Zurn, Sloan
  - B. Plumbing Trim: American Standard, Chicago Faucet, Kohler, Delta Commercial, T&S Brass, Just, Speakman, Zurn Aqua-Spec, Moen Commercial, Symmons
  - C. Flush Valves: Sloan, Zurn, Delany
  - D. Stainless Steel Sinks: Elkay, Just, Moen Commercial, Sterling
  - E. Mop Basins and Laundry Tubs: American Standard, Eljer, Fiat, Kohler, Mustee, Acorn, Zurn
  - F. Water Coolers: Elkay, Haws, Sunroc, Oasis, Halsey Taylor
  - G. Appliance Connection Boxes: Guy Gray, Oatley, Wolverine
  - H. Fixture Seats: Bemis, Church, Olsonite
  - I. Fixture Carriers: Josam, Kohler, Tyler Pipe, Zurn, Wade, Smith, Watts
  - J. Lavatory, Sink, Mop Basin and Laundry Tub Strainers: American Standard, Elkay, Kohler, McGuire., Sloan, Zurn.
  - K. P-traps, Tailpieces, and Escutcheons: American Standard, Elkay, Kohler, McGuire, Moen Commercial, Sloan, Zurn.
  - L. P-trap Insulation covering for ADA Fixtures: IPS Corp., McGuire, Plumberex.
  - M. Water supplies and stops: American Standard, Elkay, Kohler, McGuire, Moen Commercial, Nibco, Sloan, Watts, Zurn,

## PART 2 – PLUMBING FIXTURE SPECIFICATIONS:

### P-1 WATER CLOSET – FLUSH VALVE, FLOOR MOUNTED – STANDARD HEIGHT

Zurn model Z5655-BWL, vitreous china, 15” high siphon jet, elongated bowl, china bolt caps and white open front plastic seat with check hinge. Water closet flush valve shall be as follows:

- Manual flush valve shall be Zurn model Z6000-WS1.

**P-1A WATER CLOSET – FLUSH VALVE, FLOOR MOUNTED – ADA HEIGHT**

Zurn model Z5660, vitreous china, 18" high, siphon jet, 1-1/2" top spud, elongated bowl, china bolt caps and white open front plastic seat with check hinge. Install flush valve on "open" side of water closet. Water closet flush valve shall be as follows:

- Manual ADA flush valve shall be Zurn model Z6000-WS1. Top of flush valve handle shall be a maximum of 31-1/4" A.F.F. Coordinate installation with grab bar.

**P-1B WATER CLOSET – FLUSH VALVE, WALL MOUNTED – STANDARD HEIGHT**

Zurn model Z5615-BWL vitreous china, elongated rim, siphon action water closet. Provide 1½" top spud, solid plastic elongated seat with open front, extended back, and check hinge. Provide with concealed carrier. Water closet flush valve shall be as follows:

- Manual flush valve shall be Zurn model Z6000-WS1.

**P-1C WATER CLOSET – FLUSH VALVE, FLOOR SET – CHILD HEIGHT**

Zurn model Z5675-BWL, vitreous china, 10" high siphon jet, elongated bowl, china bolt caps and white open front plastic seat with check hinge. Water closet flush valve shall be as follows:

- Manual flush valve shall be Zurn model Z6000-WS1.

**P-1D WATER CLOSET – FLUSH VALVE, WALL MOUNTED – ADA HEIGHT**

Zurn model Z5615-BWL vitreous china, elongated rim, siphon action water closet. Provide 1½" top spud, solid plastic elongated seat with open front, extended back, and check hinge. Provide with concealed carrier. Mount seat at 18" AFF. Install flush valve on "open" side of water closet. Water closet flush valve shall be as follows:

- Manual ADA flush valve shall be Zurn model Z6000-WS1. Top of flush valve handle shall be a maximum of 31-1/4" A.F.F. Coordinate installation with grab bar.

**P-2 WASH FOUNTAIN**

Sloan AER-DEC Integrated sink system Model AD-83000 with built-in AirDam technology. Product to be fabricated out of Corian. Enclosure material shall be Angled Stainless Steel, Vandal resistant, ADA compliant, 0.5 GPM flow rate per station, all valving, water supplies, and waste connections are concealed inside the apron with access panel is removable only with a hex key. Unit to be provided with thermostatic mixing valve, control transformer, check stops and strainers, drain spud, flexible stainless steel supply hoses and locknut. Color to be selected by Architect. Provide three (3) Sloan model ETF 410 Series faucets, vandal resistant outlets, sensor operated, hardwired sensor faucets with polished chrome finish (Coordinate exact location of all electrical connections with electrical contractor)

**P-2A LAVATORY – WALL-HUNG, BACKSPLASH – ADA COMPLIANT**

Zurn model Z5344, 20"x18" vitreous china lavatory with backsplash, rectangular basin, splash lip, front overflow, and 4" center faucet holes. Provide with concealed arm support and wall carrier. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and P-trap. Install insulation on the supply lines and P-trap similar to Brocar "Trap Wrap" vinyl plastic covering per ADA Standards. Mounting height to be per ADA. Lavatory trim shall be as follows:

- Gooseneck faucet with wrist blade handles shall be Zurn model Z812B4-3F with polished chrome-plated cast brass faucet body on 4" centers with quarter turn ceramic disc cartridges and 5-3/8" swing gooseneck spout. Furnish with 0.5 GPM vandal-resistant aerator and 4" color-coded metal wrist blade handles.

P-3 URINAL - WALL-HUNG – STANDARD HEIGHT

Zurn model Z5755-U vitreous china, wall-hung, 1.0 GPF urinal with 3/4" top spud and concealed wall hanger brackets. Urinal flush valve shall be as follows:

- Manual flush valve shall be Zurn model Z6003-WS1.

P-3A URINAL – WALL-HUNG – ADA HEIGHT

Zurn model Z5755-U vitreous china, wall-hung, 1.0 GPF urinal with 3/4" top spud and concealed wall hanger brackets. Mounting height shall be per ADA. Urinal flush valve shall be as follows:

- Manual ADA flush valve shall be Zurn model Z6003-WS1. Install per ADA requirements.

P-4 SINGLE COMPARTMENT SINK – 19"X18"

Elkay LRAD-1918, single compartment stainless steel sink, 19" x 18" O.D., 18 gauge with 3-hole, 8" center faucet punching. Provide with grid strainer, 3/8" chrome supplies stops, tailpiece, P-trap, drain and escutcheons. Sink trim shall be as follows:

- Gooseneck faucet with wrist blade handles shall be Zurn model Z812B4-3F with polished chrome-plated cast brass faucet body on 4" centers with quarter turn ceramic disc cartridges and 5-3/8" swing gooseneck spout. Furnish with 0.5 GPM vandal-resistant aerator and 4" color-coded metal wrist blade handles.

P-4A SINK – BOWL INTEGRAL TO COUNTERTOP

Refer to architectural drawings and specifications for coordination of lavatory bowl integral to countertop. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and P-trap. Lavatory trim shall be as follows:

- Gooseneck faucet with wrist blade handles shall be Zurn model Z812B4-3F with polished chrome-plated cast brass faucet body on 4" centers with quarter turn ceramic disc cartridges and 5-3/8" swing gooseneck spout. Furnish with 0.5 GPM vandal-resistant aerator and 4" color-coded metal wrist blade handles.
- Dilution tank shall be Zurn Z9A-DT, 1.5 gallon high density polyethylene dilution tank with removable, bolted gasketed polypropylene cover with neoprene gasketing material.

P-4B SINK – BOWL INTEGRAL TO COUNTERTOP

Refer to architectural drawings and specifications for coordination of lavatory bowl integral to countertop. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and P-trap. Lavatory trim shall be as follows:

- Gooseneck faucet with wrist blade handles shall be Zurn model Z812B4-3F with polished chrome-plated cast brass faucet body on 4" centers with quarter turn ceramic disc cartridges and 5-3/8" swing gooseneck spout. Furnish with 0.5 GPM vandal-resistant aerator and 4" color-coded metal wrist blade handles.
- Dilution tank shall be Zurn Z9A-DT, 1.5 gallon high density polyethylene dilution tank with removable, bolted gasketed polypropylene cover with neoprene gasketing material.



**P-4C SINK – BOWL INTEGRAL TO COUNTERTOP**

Refer to architectural drawings and specifications for coordination of lavatory bowl integral to countertop. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and P-trap. Lavatory trim shall be as follows:

- Gooseneck faucet with wrist blade handles shall be Zurn model Z812B4-3F with polished chrome-plated cast brass faucet body on 4" centers with quarter turn ceramic disc cartridges and 5-3/8" swing gooseneck spout. Furnish with 0.5 GPM vandal-resistant aerator and 4" color-coded metal wrist blade handles.
- Dilution tank shall be Zurn Z9A-DT, 1.5 gallon high density polyethylene dilution tank with removable, bolted gasketed polypropylene cover with neoprene gasketing material.

**P-4D DOUBLE COMPARTMENT SINK – 33"X22"**

Elkay LRAD-3322, compartment stainless steel sink, 33" x 22", each bowl, 18 gauge with 3-hole, 8" center faucet punching. Provide with grid strainer, chrome supply stops, tailpiece, 17 gauge P-trap, drain and escutcheons. Sink trim shall be as follows:

- Gooseneck faucet with wrist blade handles to be Chicago Faucet 786-E3 concealed body faucet on 8" centers with swing gooseneck spout. Faucet to have cast bronze body with 4" forged brass wrist action handles, color coded indexes, Quatern operating cartridges, polished chromium plated finish and B-199-2 aerator outlet.

**P-4E DOUBLE COMPARTMENT SINK – 33"X22"**

Elkay LRAD-3322, compartment stainless steel sink, 33" x 22", each bowl, 18 gauge with 3-hole, 8" center faucet punching. Provide with grid strainer, chrome supply stops, tailpiece, 17 gauge P-trap, drain and escutcheons. Sink trim shall be as follows:

- Gooseneck faucet with wrist blade handles to be Chicago Faucet 786-E3 concealed body faucet on 8" centers with swing gooseneck spout. Faucet to have cast bronze body with 4" forged brass wrist action handles, color coded indexes, Quatern operating cartridges, polished chromium plated finish and B-199-2 aerator outlet.
- Plaster trap shall be Zurn Z-1184, Bottom Access solids interceptor.

**P-6 MOP BASIN**

Fiat MSB-24 24, 24" x 24" 10" high molded stone mop service basin in #231 white drift color and #874, 3" drain, Provide Chicago Faucet model 897-CP faucet, #832-AA hose and hose bracket, #889-CC mop hanger and #E-77-AA vinyl bumperguard. Provide with MSG stainless steel wall guards. Provide check valves on the hot and cold water supplies to the faucet.

**P-7 DRINKING FOUNTAIN WITH BOTTLE FILLER – ADA AND STANDARD HEIGHT**

Elkay model LZSTL8WSSP electric water cooler; 8.0 GPH of 50 deg F water at 90 deg F room temperature and 80 deg F entering water; stainless steel basin, 1/5 HP compressor; 115/1phase/60 HZ. Provide with non-metallic P-Trap per manufacturers specifications.

**P-8 ICE MAKER CONNECTION BOX**

IPS Corporation Water-Tite mini round ice maker outlet box with integral water hammer arrestor and preloaded nails. Connect cold water supply line to water supply at adjacent sink. Field paint exposed portions of box to match adjacent wall surfaces.

P-8A WASHING MACHINE CONNECTION BOX

Guy Gray Model #WB200HA, 2" drain outlet, 16 gauge steel with epoxy finish and integral water hammer arrestors. Field paint exposed portions of box to match adjacent wall surfaces.

P-10 EMERGENCY SHOWER AND EYE WASH

Bradley Model #S19-310LL combination drench shower/eye wash unit. Unit to be provided with 10" shower head, 1" shower valve activated by a pull bar, 10" eye wash bowl with twin, soft flow eye wash heads. Eyewash activated by 1/2" hand operated valve. Pipe and fittings to be galvanized steel painted safety yellow. Provide with thermostatic mixing valve above ceiling; Bradley S19-2100.

PART 3 - EXECUTION

- 3.1 Coordinate all stainless steel sinks with architectural casework shop drawings for appropriate fit. Do not order sinks until this has been coordinated. Change Orders will be immediately rejected for lack of coordination during construction.
- 3.2 Test for appropriate operation at least twice, ALL fixtures and trim including hands-free trim. Open all faucets and allow to run for fifteen (15) minutes, then remove all faucet aerators and thoroughly clean until smooth flow is obtained. Test by operation at least twice, adequate flow of water at flush valves including appropriate adjustment of hands-free devices, faucets including appropriate adjustment of hands-free devices, hose bibbs, fixture drains, shower heads, etc.
- 3.3 Remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from plumbing fixtures and thoroughly clean same.

END OF SECTION 224000

## SECTION 224005- PLUMBING SPECIALTIES

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall provide all equipment and specialties complete with trim required and connect in a manner conforming to the State Plumbing Code.
- 1.3 The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of the rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.
- 1.4 All equipment and specialties shall be new. All equipment and specialties shall be installed as recommended by the manufacturer.
- 1.5 Prior to final inspection, test by operation at least twice, all equipment. Also, remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from equipment and specialties and thoroughly clean same.
- 1.6 All equipment and specialties shall be installed in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost.
- 1.7 Provide all drainage specialties indicated, specified and/or required to provide complete and acceptable removal of all storm, sanitary, waste, laboratory waste, etc. from the building and into approved receptors. Drainage specialties shall be on non-electrolytic conduction to the material to which they are connected. Drainage specialties shall be installed in a manner so as to insure no leakage of toxic or odorous gases or liquids and shall have traps and/or backflow preventers where required. Nor shall they allow backflow into other or existing systems.

### PART 2 - CLEANOUTS:

- 2.1 CLEANOUTS: In addition to cleanouts indicated on the drawings, provide cleanouts in soil and waste piping and storm drainage at the following minimum locations:
  - At base of each stack.
  - At fifty (50) foot maximum intervals in horizontal lines.
  - At each change of direction of a horizontal line.
  - As required to permit rodding of entire system.
  - As required by current State Plumbing/Building Codes.
- 2.2 Water closets, mop sinks/basins and other fixtures with fixed traps shall not be accepted as cleanouts.
- 2.3 Cleanouts and/or test tees concealed in inaccessible pipe spaces, walls and other locations shall have an eight (8) inch by eight (8) inch (minimum) access panel or cover plates shall be set flush with finished floors and walls and shall be key or screw driver operable.

- 2.4 Access panels for cleanouts shall be of the Zurn 1460 series or equivalent by Josam or Wade. Where they are not to receive paint, they shall be polished bronze unless otherwise indicated where they are to receive paint or other finishes.
- 2.5 Cleanouts and access panels shall be sized so as to permit the entry of a full sized rodding head capable of one hundred percent circumferential coverage of the line served.
- 2.6 Provide a non-hardening mixture of graphite and grease on threads of all screwed cleanouts during installation.
- 2.7 Do not install cleanouts against walls, partitions, etc. where rodding will be difficult or impossible. Extend past the obstruction.
- 2.8 In finished walls, floors, etc., insure that cleanouts are installed flush with finished surfaces and, where required, grout or otherwise finish in a neat and workmanlike manner.
- 2.9 EXTERIOR CLEANOUTS (ECO): Provide exterior cleanouts where indicated for all sanitary and storm lines leaving the building within 5'-0" of building perimeter. Permanently locate all exterior cleanouts with 12"x12"x12" solid finished concrete marker slightly above grade in grass areas or flush in concrete or pavement areas. Label "CO". Zurn Z-1400-HD cleanout with tractor cover for exterior locations. Provide concrete supporting pad crowned to shed water.
- 2.10 Cleanouts shall be as manufactured by Zurn, Watts, Jay R. Smith, similar to the following:
- Zurn Z-1440 or Z-1445 cleanout tee at base of exposed stack and at change in direction of exposed lines.
  - Zurn Z-1440 cleanout or Z-1445-1 cleanout tee where stacks are concealed in finished walls.
  - Zurn ZN-1400-T cleanout with scoriated top in finished concrete and masonry tile floors.
  - Zurn ZN-1400-Tx cleanout with square recessed top for VCT and linoleum finished floors.
  - Zurn ZN-1400-Z cleanout with round recessed top for poured floors.
  - Mueller D-731 or D-714, Nibco, Flage or equivalent for cleanouts in copper waste with cover plates and/or access panels listed for other cleanouts.
  - Threaded hex head type cleanouts of same materials as pipe for piping 2" and smaller.
  - Zurn cleanout with round top with adjustable retainer for carpet area. Install flush with carpet.

### PART 3 – FLOOR DRAINS:

- 3.1 FLOOR DRAINS: Provide floor drains at locations indicated and/or as required by State Plumbing/Building Codes. Install in a neat and workmanlike manner. Install floor drains in strict accordance with manufacturer's recommendations and the State Plumbing and Building Codes. Coordinate locations with General Contractor to insure floor pitch to drain where required.
- 3.2 Insure by coordination with the General Contractor that spaces served with floor drains on all floors above the lowest level have a water seal extending at least three (3) inches from the floor. Also, for these locations, provide a 36"x36", four (4) pound sheet lead flashing sheet and clamping collar or a 30 mil chlorinated polyethylene shower pan liner. Lead pans shall be given a heavy coat of asphaltum on bottom and sides before installation and a heavy coat on any exposed surfaces. After installation, provide one ply of fifteen (15) pound roofing felt beneath each pan.

- 3.3 The floor drains shall be Zurn, Josam, Smith, Wade, Watts Drainage, Ancon, similar to the following:
- FD-1 - Zurn, ZN-415 floor drain with 6"dia. nickel bronze strainer, Type "B", dura-coated cast iron body with bottom 4" outlet. Provide with trap primer connection.
  - FD-2 - Zurn, ZN-511 floor drain with 9"dia. nickel bronze strainer, dura-coated cast iron deep sump with 4" bottom outlet, seepage pan and sediment bucket. Provide with trap primer connection.
  - FS-1 - Zurn, ZN-1900 floor drain cast iron body with white acid resisting porcelain enamel interior and top, anti-splash interior bottom dome strainer, 6" depth and 4" outlet. Provide with trap primer connection.

#### PART 5 – FREEZEPROOF WALL HYDRANTS:

- 5.1 FREEZEPROOF WALL HYDRANTS: Provide code approved wall hydrants at each location indicated in a neat and workmanlike manner. Affix tight to walls and insure that the feed piping is on the heated side of the building insulation blanket. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.
- 5.2 Wall hydrants shall be Zurn 1320 or equivalent, 3/4", with half-turn ceramic cartridge, encased, flush, non-freeze, anti-siphon, automatic draining wall hydrant with key lock and combination backflow preventer/vacuum breaker.
- 5.3 Mount all wall hydrants at least twenty (20) inches above finished exterior grade. Where this is not possible or practical, contact Engineer for direction.
- 5.4 Turn over for each hydrant, an operator key in an envelope labeled "Exterior Wall Hydrants" to Owner upon completion of the project. Where hydrants have lockable boxes, turn over an operator key for each in an envelope labeled "Exterior Wall Hydrant Locks" to Owner upon completion of project.

#### PART 6 – INTERIOR HOSE BIBBS AND DRAIN VALVES:

- 6.1 HOSE BIBBS AND DRAIN VALVES: Provide code approved hose bibbs and drain valves at each location indicated in a neat and workmanlike manner. Affix hose bibs tight to walls. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.
- 6.2 HOSE BIBBS (HB): Provide code approved hose bibbs with vacuum breakers and male threaded spouts at each location indicated (toilet rooms, mechanical rooms, etc.). The hose bibbs shall be Woodford Model B24 (or equal) concealed, with loose key handle polished chrome finish, brass construction. Hose bibbs shall be mounted at eighteen (18) inches above finished floor. Do not install hose bibbs in spaces which do not have floor drains. Do not install exposed hose bibbs in ADA accessible toilet stalls.

- 6.3 HOSE BIBBS (HB-1): Provide code approved hose bibbs with vacuum breakers and male threaded spouts at each location indicated (toilet rooms, mechanical rooms, etc.). The hose bibbs shall be Woodford Model 24 (or equal) concealed, with loose key handle polished chrome finish, brass construction. Hose bibbs shall be mounted at eighteen (18) inches above finished floor. Do not install hose bibbs in spaces which do not have floor drains.
- 6.4 DRAIN VALVES: Install 3/4 inch bronze body drains, similar and equivalent to Nibco, No. 72 or 73, as indicated and at the following locations:
- At the low point and isolatable section of the plumbing system.
  - At each low point and isolatable section of the hydronic system.
  - At each isolatable pipe section.
  - At each water heater.
  - At each storage tank.
  - At each boiler.
  - At each heat pump.
  - At each water-to-water unit.
  - At each chiller.
  - At each pump suction.
  - Install a code approved vacuum breaker where installation on to domestic water system.

#### PART 7 – WATER HAMMER ARRESTORS (WHA):

- 7.1 WATER HAMMER ARRESTORS (WHA): Provide water hammer arrestors at each location indicated and/or as required to eliminate hydrostatic on the domestic water system. Install in an accessible location and in a neat and workmanlike manner. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.
- 7.2 Water hammer arrestors shall be Zurn, Z-1700, Shoktrol, Smith, Josam, Wade or equivalent. Water hammer arrestors shall be stainless steel, bellows type. Field fabricated capped cylinders shall not be acceptable. Provide insulating unions where arrestors are of dissimilar material from the piping served (unless piping is non-conducting, such as ABS or PVC).
- 7.3 MULTIPLE FIXTURES – BRANCH LINE LESS THAN 20' LONG: The preferred location for a Zurn Shoktrol is at the end of the branch line between the last two fixtures served when the branch lines do not exceed 20' in length, from the start of the horizontal branch line to the last fixture supply on this line.
- 7.4 MULTIPLE FIXTURES – BRANCH LINE MORE THAN 20' LONG: On branch lines over 20' in length, use two Shoktrols whose capacities total the requirement of the branch. Locate one unit between the last and next to last fixture and the other unit approximately midway between the fixtures.
- 7.5 Provide at least one water hammer arrestor at all quick acting valve locations including:
- Clothes Washers – Type "A"
  - Commercial Dishwashers – Type "B"
  - Mop Basins, downstream of check valves – Type "A"

- Flush valve fixtures – Type “B”, each toilet room with 1-3 flush valve fixtures shall have its own Type “B” water hammer arrestor.

7.6 ARRESTOR SCHEDULE:

|          | Zurn Model | Fixture | P.D.I. |
|----------|------------|---------|--------|
| Mark     | Z-1700     | Units   | Size   |
| Type “A” | #100       | 1-11    | A      |
| Type “B” | #200       | 12-32   | B      |
| Type “C” | #300       | 33-60   | C      |
| Type “D” | #400       | 61-113  | D      |

PART 8 - OTHER SPECIALTIES:

- 8.1 VACUUM BREAKERS AND BACK FLOW PREVENTERS: Where required by the Building Code, whether indicated or not, provide approved vacuum breakers or backflow preventers at the following locations.
- Where domestic water system connects to a limited area fire protection system.
  - Where domestic water system connects to hydronic system.
  - At any threaded hose tap on the domestic water system.
  - At all mop basins, provide check valves to the hot and cold water supply upstream of the faucet.
- 8.2 ROOF FLASHINGS: All plumbing vents or other plumbing passing thru the roof shall be flashed as approved by the State Plumbing and Building Codes and as recommended by the roofing manufacturer and/or Contractor.
- 8.3 LINT INTERCEPTOR: Provide steel fabricated lint interceptor with acid resistant coating on interior and exterior with non-skid cover and removable lift handle. An aluminum primary and secondary screen assembly shall be provided with straining baffle with a 3/8” diameter perforated holes. Provide stainless steel tamper resistant securing hardware. Provide an extension collar for invert elevation of the inlet piping to maintain a minimum of 12” below finished floor. Field verify. Provide at all washing machine locations.

PART 10 – THERMOSTATIC MIXING VALVE:

- 10.1 TMV–1: Bradley S59-3080 thermostatic mixing valve. Thermostatic mixing valve shall be of lead-free brass design, liquid filled thermostat with 10 year warranty, integral checkstops on inlets, adjustable set point within temperature range accurate within +/- 3°. Fail safe shall provide positive shutoff in the event of the cold-water line failure, or, thermostat failure. Thermostatic mixing valve shall be mounted to the wall, exposed. Minimum flow shall be 2 GPM at 15 PSI pressure drop at 44 GPM. A ½” hot water return line shall be connected as per Bradley Corp. installation schematics indicated.

PART 11 – GREASE INTERCEPTOR:

- 11.1 GT-1: Provide Schier model GB-1000 or Oldcastle Precast 1500 gallons precast grease interceptor. Grease interceptor shall be provided with (2) two 24" diameter manhole covers labeled "GREASE". Interceptors shall be provided with manhole extension rings, contractor shall field verify exact dimensions in field prior to ordering. Grease interceptor shall be traffic rated for H20 loading and stamped for construction by structural engineer by manufacturer. Quantity of grease interceptors shall be as indicated on the contract drawings. Intermediate baffles shall be installed / designed in accordance with Virginia City of Harrisonburg requirements.

PART 12 – TRAP PRIMER:

- 12.1 Trap Primer: Provide Precision Plumbing Products PR-500 "Prime-Rite" Series trap primer valve. Trap primer valve shall be constructed of 360 corrosion resistant brass, automatic pressure drop activated. System operating range shall be 20 PSI – 80 PSI and installed on a branch line which will provide a 10 PSI pressure drop across the valve to activate.

END OF SECTION 224005



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## SECTION 230500 - COMMON WORK RESULTS FOR HVAC

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

#### 1.2 SCOPE

- A. The Advertisement for Bid, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.
- B. All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals for any part of the work, services, materials or equipment to be used on or applied to this project are hereby directed to familiarize themselves with the Contract Documents. In case of conflict between these General Provisions and the General and/or Special Conditions, the Contractor shall contact the Engineer for clarification and final determination prior to the Bid.
- C. The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, and appurtenances and services necessary for the satisfactory installation of the complete and operating Mechanical Systems indicated or specified in the Contract Documents.
- D. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete any part of the Mechanical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.
- E. It is not the intent of this Section of the Specifications to make any Contractor, other than the Construction Manager responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the Construction Manager to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.
- F. The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer's convenience and is not intended to define a subcontractor's scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Contract Documents when preparing Bids, prices and quotations. Unless stated otherwise, the subdivision

and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

- G. It is the intent of the Contract Documents to deliver to the Owner a new, complete and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.
- H. In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least seven (7) days prior to the interruption of any services (gas, domestic water, heating, etc.). The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.
- I. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Bidder/Proposer's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation from the Owner.
- J. Each Bidder/Proposer shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.

### 1.3 DEFINITIONS AND ABBREVIATIONS:

- A. Contractor - Any Contractor whether bidding, proposing or working independently or under the supervision of a Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the Construction Manager.
- B. Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
- C. Architect - The Architect of Record for the project.
- D. Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owner, etc.
- E. Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.
- F. The Project - All of the work required under this Contract.
- G. Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
- H. Provide - Furnish and install complete, tested and ready for operation.

- I. Install - Receive and place in satisfactory operation.
- J. Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto.
- K. Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
- L. ADA - Americans with Disabilities Act.
- M. ANSI - American National Standards Institute.
- N. ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.
- O. ASME - American Society of Mechanical Engineers.
- P. IBC - International Building Code.
- Q. NEC - National Electrical Code.
- R. NEMA - National Electrical Manufacturers Association.
- S. NFPA - National Fire Protection Association.
- T. OSHA - Office of Safety and Health Administration.
- U. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.
- V. UL - Underwriters Laboratories.

#### 1.4 INTENT AND INTERPRETATION:

- A. It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.
- B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
- C. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
- D. The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be

required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.

- E. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten (10) days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

#### 1.5 PLANS AND SPECIFICATIONS:

- A. The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Plans are not intended to show every item which may be necessary to complete the systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.
- B. The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.
- C. The Plans and Specifications shall be considered to be cooperative and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
- D. Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.
- E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.
- F. Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.
- G. Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.
- H. Each Bidder/Proposer shall review all Plans in the Contract Documents to ensure that the work they intend to provide does not create a conflict with or affect the work of others in any way.

Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular ensure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.

- I. Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.
- J. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
- K. Where within the Contract Documents the word "typical" or "typ." is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.
- L. Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.
- M. The Contractor shall provide a layout confirmation of equipment rooms to verify that all of the equipment submitted and approved will in fact fit into the proposed space and have adequate clearance for service. See COORDINATION DRAWINGS SECTION.

#### 1.6 EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

- A. When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, that the design allows for it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.
- B. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be

interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part are met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of cities, towns, states or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

- C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.
- D. Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.

#### 1.7 QUALIFICATIONS OF CONTRACTOR/WORKERS:

- A. All Mechanical Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.
- B. All mechanical subcontractors bidding the mechanical work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.
- C. All mechanical work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workers and unqualified or incompetent workers shall refrain from work in areas not deemed satisfactory. Requests for relief of workers shall be made through the normal channels of Architect, Contractor, etc.
- D. The Contractor shall hold all required licenses in the State which the work is to be performed.
- E. The installation of all Heating, Ventilating and Air-Conditioning Systems (HVAC) by any Contractor, whether in existing or new building construction shall be performed by a Licensed Master HVAC Contractor. This includes any Contractor installing HVAC systems, piping and ductwork.
- F. All sheet metal, insulation and pipe fitting work shall be installed by workers normally engaged in this type work.
- G. All electrical work shall be accomplished by Licensed Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

#### 1.8 HAZARDOUS MATERIALS:

- A. Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.
- B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.
- C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.
- D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.
- E. No asbestos or mercury containing materials shall be installed in this project.
- F. No asbestos - containing materials are to be purchased, supplied by any person supplying or installed in or on property by any person performing work. Furthermore, all products marked "May contain Mineral Fiber" will be assumed to contain asbestos unless the manufacturer provides written certification that no asbestos fibers are present in the product and identifies the fibers for which the product is marked. An exception to this rule can be made where a faculty or staff member certifies that the use of asbestos is essential to an ongoing research or production project and works with Environmental Health and Safety Department to ensure that the material is used, stored and disposed of in safe and legal manner.

#### 1.9 COORDINATION DRAWINGS:

- A. Detailed electronic coordination drawings shall be required for this project. A specific line-item shall be included on the schedule of values by each Trade for "preparation of coordination drawings". This line-item value shall be approved by the Engineer. The Engineer and the Engineer's Field Inspector shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.
- B. Coordination Drawings shall be provided on this project. Drawings shall be prepared in electronic format utilizing AutoCad or similar drafting software. The Architect and Engineer will supply electronic drawings files of the Contract Documents upon the Contractor's request and release.

- C. The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits and other conduits 2" and larger, and piping and components in ceiling spaces. The Coordination Drawings shall be prepared by the Fire Protection Contractor. The Coordination Drawings shall indicate (1) systems above ceilings in finished areas, (2) systems supported from the structure in finished areas without ceilings, (3) systems in the mechanical rooms, and (4) all wall, roof, floor penetrations.
- D. Pre-Coordination Meetings with all necessary trades shall occur. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc will be installed with respect to the sheetmetal fabrication drawings and other trades. The sheetmetal ductwork and gravity piping systems shall be given the first priority. Each Trade shall provide the Mechanical Contractor electronic drawings of all of their systems (with elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings shall then occur so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at these Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.
- E. It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
1. All supply/return/exhaust ductwork.
  2. All above slab sanitary and roof drainage piping.
  3. HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
  4. Electrical conduits which are 1.5" in size and greater.
  5. Cable tray and bridal ring paths.
  6. Multiple smaller piping/conduits hung on a common trapeze hanger.
  7. All wall, roof, floor penetrations.
- F. After completion of the Final Coordination Drawings, a Final Review with the all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meetings will be required to insure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed electronically (on CD) to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete 30x42 paper set of drawings to the jobsite main office and shall utilize them for updates of field conditions/deviations that occur during construction. Final Approved Coordination Drawings shall also be distributed to the Prime Contractor, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.
- G. Each Contractor shall insure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on Coordination Drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site



especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Prime Contractor, Owner, Architect and Engineer for their Records.

- H. The Mechanical contractor is responsible to the Construction Manager for the shop drawing layout of the following rooms and details:
1. Concrete pads
  2. Equipment room layouts with actual equipment
  3. Roof layouts
  4. Congested areas above ceilings adjacent to mechanical and electrical room
  5. Dimensioned ductwork shop drawings

## PART 2 - PRODUCTS (NOT APPLICABLE)

## PART 3 – EXECUTION

### 3.1 EXAMINATION OF SITE CONDITIONS

- A. Each Bidder/Proposer shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.
- B. Each Bidder/Proposer shall also fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

### 3.2 CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:

- A. The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, inspections and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.
- B. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.
- C. The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus and plans in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.
- D. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

- E. All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of, or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.
- F. All Heating, Ventilation and Air Conditioning work shall be accomplished in accordance with the Building Code and amendments thereto, the latest standards recognized by the American Society of Heating, Refrigerating and Air Conditioning and the National Fire Protection Association.
- G. The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.
- H. Where minimum code requirements are exceeded in the Design, the Design shall govern.
- I. The Contractor shall insure that their work is accomplished in accord with the OHSA Standards and that they conduct their work and the work of their personnel in accord with same.
- J. All work relating to the handicapped shall be in accord with regulations currently enforced by the Authority Having Jurisdiction and the American Disabilities Act.
- K. Discharge of any toxic, odorous or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.
- L. Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense.

### 3.3 SUPERVISION OF WORK:

- A. The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

### 3.4 CONDUCT OF WORKERS:

- A. The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt removal of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or debilitating drugs on the job site is strictly forbidden.

### 3.5 COOPERATION AND COORDINATION WITH OTHER TRADES:

- A. The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.
- B. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so, directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than  $\frac{1}{4}" = 1'-0"$ , clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.
- C. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

### 3.6 GUARANTEES AND WARRANTIES:

- A. The Contractor shall guarantee all equipment, apparatus, materials, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective within the time frame outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Project's Statement of final acceptance. Items of equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.
- B. All VFD's shall have a two-year warranty. (Parts and Labor).
- C. Provide all warranty certificates to Owner. All warranties begin starting at the final acceptance date, submit warranty certificates accordingly.

### 3.7 COST BREAKDOWNS (SCHEDULE OF VALUES):

- A. Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.
- B. The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc.:

1. Mechanical Shop Drawings
2. Motor Load Coordination with other subcontractors
3. Mechanical Record Drawings & Acceptance
4. Mechanical O&M Manuals & Acceptance
5. Mechanical Owner Training & Acceptance
6. Spare Parts
7. Coordination Drawings
8. Mechanical Identification Materials & Labor
9. HVAC Piping Materials & Labor
10. HVAC Piping Testing, Cleaning, Documentation, Acceptance, etc.
11. HVAC Piping Purging, Flushing, Cleaning
12. Insulation (Piping) Materials & Labor
13. Insulation (Ductwork) Materials & Labor
14. Sheetmetal Equipment
15. Sheetmetal Materials & Labor
16. Sheetmetal Shop Fabrication
17. Ductwork Air Leakage Testing, Documentation, Acceptance, etc.
18. Filters and Racks Materials & Labor
19. Heat Pump Equipment & Labor
20. Heat Pump Startup, Testing, Documentation, Training, Acceptance, etc.
21. Other HVAC Equipment & Labor
22. Other HVAC Equipment Startup, Testing, Documentation, Training, Acceptance, etc.
23. Chemical Treatment Materials & Labor
24. Chemical Treatment Pre-Testing
25. Chemical Treatment Startup, Testing, Documentation, Training, Acceptance, etc.
26. Controls Front-end Interface
27. Controls Commissioning Plan
28. Controls Shop Drawings
29. Controls Materials & Labor
30. Controls Graphics
31. Controls Record Drawings
32. Controls Startup, Commissioning, Testing, Documentation, etc.
33. Controls Training and Acceptance
34. Test and Balance Materials & Labor
35. Test and Balance Pre-Testing
36. Test and Balance Initial Report, Final Report and Acceptance

3.8 CHANGES IN MECHANICAL WORK:

- A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.9 CLAIMS FOR EXTRA COST:

- A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.10 MATERIALS AND WORKMANSHIP:

- A. All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the

space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and/or disassemble/reassemble the materials and equipment and this work shall be the responsibility of the Contractor, whether specifically initiated or not.

- B. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of fans, motors, coils, filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Insure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.
- C. Materials and equipment shall bear Underwriters' Laboratories label where such a standard has been established, where applicable.
- D. All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a name plate indicating required horsepower, voltage, phase and ampacity. Pumps and fans shall have a data plate indicating horsepower, pressure and flow rate.

### 3.11 TEMPORARY SERVICES:

- A. The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.
- B. All temporary services shall be removed by Contractor prior to completion of work.

### 3.12 SURVEY, MEASUREMENTS AND GRADE:

- A. The Contractor shall lay out their work and be responsible for all necessary lines, levels, inverts, elevations and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.
- B. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.
- C. Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

### 3.13 PROTECTION OF EQUIPMENT:

- A. The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged, stolen or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense. All ductwork with open ends shall be covered with plastic during construction.

3.14 REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:

- A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, ductwork, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost. Coordinate with the Electrical Contractor prior to any work.

3.15 EQUIPMENT SUPPORT:

- A. Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

3.16 DUCT AND PIPE MOUNTING HEIGHTS:

- A. All exposed or concealed ductwork, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping and ductwork shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping. Minimum height above ceilings shall be 6" clear including insulation, unless otherwise noted.

3.17 BROKEN LINES AND PROTECTION AGAINST FREEZING:

- A. No conduits, piping, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. Do not install piping across or near openings to the outside whether or not they are carrying static or moving fluids. Insulation on piping does not necessarily insure that freezing will not occur. If in doubt, contact the Engineer.

3.18 WEATHERPROOFING:

- A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as specified and approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.
- B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

3.19 ACCESSIBILITY:

- A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and ceilings for the proper installation of their work.

They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.

- B. The Contractor shall locate and install all equipment so that it may be serviced, and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, controls, coils, etc.
- C. Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

### 3.20 SCAFFOLDING, RIGGING AND HOISTING:

- A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

### 3.21 CONCRETE WORK:

- A. The Contractor shall be responsible for the provisions of all concrete work required for the installation of any of their systems or equipment. The Contractor may, at their option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of their responsibilities relative to dimensions, quality of workmanship, locations, etc.
- B. In the absence of other concrete Specifications, all concrete related to Mechanical work shall be 3500 psi minimum compression strength at 28 days curing, slump:  $4'' \pm 1''$ , air entrainment 4.5% water to cement ratio 0.5 and shall conform to the standards of the American Concrete Institute Publication AC1-318. Heavy equipment shall not be installed on pads for at least seven (7) days after pour. Insert 6-inch steel dowel rods into new and existing floors to anchor pads.
- C. All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18" in width shall be reinforced with  $\frac{1}{2}''$  deformed round bars on 6" centers both ways. Bars shall be approximately 2" above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all vertical edges  $\frac{3}{4}''$  and tool horizontal edges with  $\frac{3}{4}''$  radius.
- D. In general, unless otherwise noted, concrete pads for equipment shall be 4" thick, extend six (6) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

### 3.22 RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:

- A. Refer to Civil Plans and Specifications.

### 3.23 MAINTENANCE OF EXISTING UTILITIES AND LINES:

- A. The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily. Provide a seven (7) day written notice to Engineer, Architect and Owner prior to interrupting any utility service or line.
- B. Known utilities and lines as available to the Engineer are shown on the Plans. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Hand dig if required to locate. Contractor shall bear costs of repairing damaged utilities.
- C. If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation in the respective area. Hand dig if required to locate.
- D. Cutting into existing utilities and services shall be performed in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.
- E. The Contractor shall repair to the satisfaction of the Owner and Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.
- F. Machine excavation shall not be permitted with ten feet of gas lines, fuel lines, electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only in accord with utility company, agency or other applicable laws, standards or regulations.
- G. Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.
- H. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

### 3.24 CLEANING:

- A. The Contractor shall, at all times, keep the area of their work presentable to the public and clear from rubbish and debris caused by their operations; and at the completion of the work, they shall remove all rubbish, debris, all of their tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.
- B. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease,



dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

- C. Ductwork and piping shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork or insulation (pipe or duct) if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

### 3.25 TEMPORARY USE OF EQUIPMENT:

- A. The permanent heating when installed, may be used for temporary services, with the consent of the Engineer. Should the permanent systems be used for this purpose the Contractors shall make all temporary connections required at their expense. They shall also make any replacement required due to damage wear and tear, etc., leaving the same in "as new" condition.
- B. Permission to use the permanent equipment does not relieve the Contractors from the responsibility for any damages to the building construction and/or equipment which might result because of its use.
- C. Warranties shall begin at final acceptance regardless of temporary use of equipment or not.
- D. A pre-start-up conference shall be held in accordance with EQUIPMENT/CONTROLS START-UP AND VERIFICATION in this section.
- E. For Heat Pump Units during all phases of construction:
  - 1. At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of filter media at final acceptance. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.
  - 2. On the outside of all exhaust air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the "construction" filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.
  - 3. At final acceptance of the project the entire unit shall be cleaned to present a like "new" unit for the Owner and all filters shall be replaced with new.
- F. For Outside Air Units during all phases of construction:
  - 1. These units shall not be used for temporary heating and cooling by the Contractor. They shall, however, be made operational, tested, etc. as specified during construction by the Contractor. Three complete sets of filters are required for each unit. In each unit, install one set of filters during construction. In each unit, install one set of filters at final acceptance.

For each unit, leave third set of filters in boxes in appropriate mechanical room as a spare set for the Owner. Dispose of all construction filters.

2. At final acceptance of the project the entire unit shall be cleaned to present a like “new” unit for the Owner and all filters shall be replaced with new.

### 3.26 NOISE, VIBRATION OR OSCILLATION:

- A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at their expense.
- B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports whether indicated or not suitable for the purpose of minimizing noise and vibration transmission, and shall be isolated from external connections such as piping, ducts, etc. by means of flexible connectors, vibration absorbers, or other approved means.
- C. Unitary equipment, such as room units, exhaust fans, etc., shall be rigidly braced and mounted to wall, floor or ceiling as required and tightly gasketed and sealed to mounting surface to prevent air leakage and to obtain quiet operation. Flush and surface mounted equipment such as diffusers, grilles, etc., shall be gasketed and affixed tightly to their mounting surface.
- D. The Contractor shall provide supports for all equipment they furnish. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineer.

### 3.27 EQUIPMENT/CONTROLS STARTUP & VERIFICATION:

- A. The Contractor and their Subcontractors shall include in the bid to provide equipment and controls startup and verification for ALL Mechanical Systems specified for this project.
- B. A pre-start-up conference shall be held with the Architect, Engineer, Owner, Construction Manager, Mechanical Contractor, Electrical Contractor, Controls Contractor, Test and Balance Contractor, and the Manufacturer’s providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.
- C. Specific line-items shall be included on the schedule of values by each Trade for “equipment and controls startup”. These line-item values shall be approved by the Engineer. The Engineer, Owner and the Engineer’s Field Inspector(s) shall closely monitor progress and quality of the equipment and controls startup and may withhold pay requests as deemed appropriate until satisfactorily completed.
- D. Specific startup/verification specifications are included throughout the Mechanical Specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians, not third-party contractors, and shall complete and submit start-up reports/checklists. The Contractor shall have appropriate trades on site to correct all deficiencies

noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up. All information shall be completed by the Contractor and submitted to the Owner/Engineer prior to acceptance of the equipment.

- E. The Contractor shall be responsible for completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment noted. Unless noted otherwise, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include the following:
  - 1. Outside Air Units
  - 2. Variable Frequency Drives
  - 3. Heat Pumps – (Include attached forms in documentation)
- F. Except for the specific equipment specified in this Specification Section, the manufacturer's recommended startup procedures and checklists will be acceptable for use in the project. Where "manufacturer" startup is not specified, then this Contractor shall perform startup services in strict accordance with manufacturer's instructions. All startup/verification process shall be thoroughly documented by the Contractor and shall include the time and date when performed.
- G. The Contractor shall "zip-tie" a start-up report to each piece of equipment in a clear plastic cover. Once start-up completion is verified by the Engineer the Contractor shall remove all reports and consolidate them into close-out documentation. The Contractor shall be responsible for completion of System Verification Checklist (SVC) / Manufacturer's Checklists.

### 3.28 INSPECTION, APPROVALS AND TESTS:

- A. Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installations to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.
- B. The Contractor shall provide as a part of this Contract any required Agency inspection, licensed and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.
- C. The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing the work. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all rough-in without fail. Failure of the Inspecting Agency to inspect the work in a timely manner and submit the related reports may result in the Contractor having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.
- D. Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.

- E. Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspector to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

3.29 ABOVE-CEILING AND FINAL PUNCH LISTS:

- A. The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.
- B. Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.
- C. When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review. The Contractor's representative may be requested at the inspections.

3.30 OPERATING INSTRUCTIONS:

- A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of three (3) days of eight (8) hours each, or as otherwise specified. Refer to Section HVAC EQUIPMENT for additional requirements. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.
- B. Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft form, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Refer to Specification Section SHOP DRAWINGS for additional detail.
- C. Each Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

3.31 RECORD DRAWINGS:

- A. The Contractor shall insure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record

documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.

- B. All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State in which the project is being constructed. This shall include underground geothermal piping mains. The survey shall include actual pipe depths to top of pipe every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on a compact disc in AutoCad “.dwg” format and “.pdf” format. The survey information shall be included in the closeout documentation.

### 3.32 COMMISSIONING: CONTRACTOR RESPONSIBILITIES:

- A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
  - 1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
  - 2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
  - 3. Attend commissioning team meetings.
  - 4. Integrate and coordinate commissioning process activities with construction schedule.
  - 5. Complete electronic construction checklists as Work is completed and provide to the Commissioning Authority.
  - 6. Review and accept commissioning process test procedures provided by the Commissioning Authority.
  - 7. Complete commissioning process test procedures.
  - 8. A manufacturer authorized technician, controls contractor, and mechanical contractor shall demonstrate the full sequence of operation and bas point integration.

END OF SECTION 230500

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## SECTION 230501 - SCOPE OF THE HVAC WORK

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

#### 1.2 SCOPE

- A. The Mechanical work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include but is not necessarily limited to the following paragraphs.
- B. Installation of all equipment per the manufacturer's instruction, whether specifically detailed or not.
- C. Provide all required motor starters, etc. not provided under the electrical sections.
- D. Thorough instruction of the Owner's maintenance personnel in the operation and maintenance of all mechanical equipment.
- E. Thorough coordination of the installation of all piping, ductwork, equipment and any other material with other trades to insure no conflict in installation.
- F. Approved supervision of the mechanical work.
- G. Procurement of all required inspections, including fees for all inspection services and submission of final certificates of inspection to the Engineers.
- H. Cutting, patching, sleeving, concrete work, etc., required to construct the mechanical systems.
- I. Cutting, patching, sleeving, concrete work, etc., required to construct the HVAC systems.
- J. Equipment and controls start-up, verification and documentation as specified.
- K. Record drawings, final inspection certificates, test results, O & M documentation, warranty certification, spare parts and other specified closeout documentation.
- L. Required schedule of values breakdown.
- M. Preinstallation meetings and equipment mockups.
- N. Complete heating, ventilation and air conditioning systems.

- O. All mechanical exhaust systems.
- P. Pipe, duct and equipment identification.
- Q. All insulation associated with mechanical systems.
- R. Condensate drainage systems.
- S. All required pressure testing, flushing, purging, pressure and flow testing requirements.
- T. All required controls, including self checkout and commissioning.

END OF SECTION 230501



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SECTION 230502 - SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS FOR  
HVAC

PART 1 – GENERAL:

1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. METERS AND GAGES FOR HVAC PIPING
  - 2. GENERAL DUTY VALVES FOR HVAC PIPING
  - 3. DUCT INSULATION.
  - 4. HVAC PIPING INSULATION
  - 5. INSTRUMENTATION AND CONTROL FOR HVAC
  - 6. FACILITY MONITORING SYSTEM
  - 7. VARIABLE FREQUENCY MOTOR CONTROL
  - 8. HYDRONIC PIPING
  - 9. HYDRONIC PUMPS
  - 10. HVAC WATER TREATMENT
  - 11. METAL DUCTS
  - 12. AIR DUCT ACCESSORIES
  - 13. DIFFUSERS, REGISTERS & GRILLES
  - 14. DEDICATED OUTDOOR-AIR UNITS
  - 15. WATER-SOURCE UNITARY HEAT PUMPS

1.2 SCOPE

- A. The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 1 requirements for shop drawing submittal requirements.
- B. The Engineer's review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations and information that pertains to fabrication and installation; dimensions. weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.

PART 2 – PRODUCTS:

2.1 SHOP DRAWINGS

- A. Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Access Doors  
Air Filtration & Components  
Cabinet Heaters  
Chemical Treatment and Test Reports  
Dedicated Outside Air Unit  
Ductwork Accessories/Volume Dampers  
Firestopping (2.5)  
Water Source Heat Pump Units  
Metal Ducts & Fittings  
Facility Management System (2.2.B; 2.2.C)  
Instrumentation and Control for HVAC (2.2.B; 2.2.C)  
Exhaust Fans  
Air Separator and Expansion Tank  
Insulation  
Meters and Gages  
Louvers  
Hydronic Piping  
Pumps and Hydronic Specialties (2.4)  
Register, Grilles & Diffusers (2.3)  
System Verification Check Lists  
Valves  
Variable Frequency Drives  
Water to Water Heat Pump  
Geothermal Piping, Specialties

(Refer to the corresponding Special Notes.)

## 2.2 SPECIAL NOTES

- A. For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:
1. Detailed operating instructions
  2. Detailed maintenance instructions including preventive maintenance schedules.
  3. Addresses and phone numbers indicating where parts may be purchased.
  4. Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
  5. Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.
  6. Start-up reports, service records and test reports.
- B. Shop drawings for the Facility Monitoring System & Instrumentation and Control for HVAC, shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system.
1. The TCC shall not start the project installation until the shop drawing submittals have been reviewed by the Engineer.

2. Submittals shall include hardware, end devices, ancillary control components, a written operating sequence, unitary control wiring, building floor plans showing communication cabling and labels as well as logic flow diagrams. All submittals shall be provided on paper and electronically in PDF format.
3. Submittals shall contain one control drawing per specified system and equipment. Drawing shall include point descriptors (DI, DO, AI, AO), addressing, and point names. Each point names shall be unique (within a system and between systems). For example, the point named for the mixed air temperature for AHU #1, AHU #2, and AHU #3 shall not be MAT but should be named AHU#1MAT, AHU#2MAT, and AHU#3MAT. The point names should be logical and consistent between systems and AHU's. The abbreviation or short hand notation (e.g., MAT) shall be clearly defined in writing by the TCC.
4. Control diagrams shall identify: System being controlled (attach abbreviated control logic text, all digital points, analog points, virtual points, all functions (logic, math, and control) within control loop, legend for graphical icons or symbols, definition of variables or point names and detailed electric connections to all control devices and sensors.
5. Points list shall include all physical input/output. Points list shall be provided in both hard copy and in electronic format and shall include: Name, address, engineering units, high and low alarm values and alarm differentials for return to normal condition, default value to be used when the normal controlling value is not reporting, message and alarm reporting as specified, identification of all adjustable points and description of all points.
6. Submittals shall contain floor plans depicting DDC control devices (control units, network devices, LAN interface devices, and power transformers as well as static pressure sensor in duct and temperature sensors in rooms) in relation to mechanical rooms, HVAC equipment, and building footprint.
7. Submittals shall contain DDC system architecture diagram indicating schematic location of all control units, workstations, LAN Interface devices, gateways, etc. Indicate address and type for each control unit, Indicate protocol, baud rate, and type of LAN per control unit.
8. Electrical wiring diagrams shall include motor start, control, and safety circuits and detailed digital interface panel control point termination diagrams with all wire numbers and terminal block numbers identified. Indicate all required electrical wiring. Provide panel termination drawings on separate drawings. Clearly differentiate between portions of wiring that are existing, factory-installed and portions to be field-installed.
9. Show all electric connections of the controls system to equipment furnished by others complete to terminal points identified with manufacturer's terminal recommendations.
10. TCC shall provide one complete drawing that shows the control-wiring interface with equipment provided by others.
11. Submittals shall include project specific graphic screens for each system including a picture of the screen with a list of the variables to be placed on the screen.
12. Submittals shall include TCC's hardware checkout sheets and test reports.

13. Submittals shall include the agenda for approval by the engineer and owner of the specified training periods. See training section for requirements.
  14. Provide complete panel drawings that are:
    - Clearly labeled and schematic or drawn to scale.
    - Show the internal and external component arrangement so that the operators can identify the components by their position if the labels come off.
    - Wiring access routes shall also be identified so that Class 1 wiring is separated from Class 2 and 3 and so high voltage wiring is segregated from low voltage wiring.
    - Complete identification of all control devices (manufacturer's type, number, and function).
    - Provide details for labeling all wiring, control devices, and controllers.
    - Material and equipment descriptive material such as catalog cuts, diagrams, performance curves, and other data to demonstrate conformance with specifications shall be provided.
  15. Include room schedule including a separate line for each terminal unit, heat pump, etc. indicating location and address.
  16. Include control valve schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: code number, configuration, fail position, pipe size, valve size, body configuration, close-off pressure, capacity, valve Cv, design pressure, and actuator type.
  17. Include control damper schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: code number, fail position, damper type, damper operator, duct size, damper size, mounting, and actuator type.
- C. O&M manuals and closeout documents for facility monitoring systems and control for HVAC and variable frequency motor control.
1. Refer to Mechanical Specification Section – REQUIRED SHOP DRAWINGS, ETC. for additional requirements.
  2. Operating instructions, maintenance procedures, parts and repair manuals shall be supplied. Repair manuals shall include detailed instructions in the setup, calibration, repair and maintenance of all equipment furnished. Also supplied with these manuals will be a complete parts listing of all devices supplied which is to include part numbers and model numbers of all parts and component parts along with exploded views of devices.
  3. All as built drawings (wiring diagrams, flowcharts, floor plans, etc.) shall also be supplied to the owner electronically in PDF format.
  4. System specific wiring, control diagrams, sequence of operation and points lists shall be as installed in each control panel. This means as-built drawings, not design (submittal) drawings.
  5. Supply all software necessary for configuration of, modification, editing or communicating to any of the unitary devices. Software shall be capable of uploading and down-loading the entire unitary data base or any part of the automated system for backup or archiving.
  6. Supply one copy of the software programming manual (hard copy and PDF format). The manual shall describe all furnished software. The manual shall be oriented to

- programmers and shall describe calling requirements, data exchange requirements, data file requirements, and other information necessary to enable proper integration, loading, testing, and program execution.
7. Provide a Bill of Materials with each schematic drawing. List all devices/equipment and match to schematic and actual field labeling. Provide quantity, manufacturer, actual product ordering number, description, size, accuracy, operating ranges (voltage, temperature, pressure, etc.), input/output parameters, etc.
  8. Maintenance manual shall include copies of signed-off acceptance test forms, commissioning reports, start-up reports, etc.
  9. The TCC shall turn over to owner two (2) sets of computerized back-ups of the complete temperature control system.
- D. The Contractor shall submit shop drawings for the kitchen range hood system(s) along with all required supporting documentation agency and review fees to the authority having jurisdiction and receive approval prior to submittal to the Engineer. Refer to Specification Section – HVAC EQUIPMENT and Specification Section SHEETMETAL for additional requirements.
- E. The Contractor shall submit shop drawings for the boilers along with all required supporting documentation and agency review fees to the authority having jurisdiction and receive approval prior to submittal to the Engineers.
- 2.3 Shop drawings for Diffuser, Registers and Grilles, shall include a room-by-room schedule indicating devices installed. Also note ceiling and installation.
- 2.4 Shop drawings shall be submitted as required and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.
- 2.5 The Contractor shall submit project specific UL listed firestopping installation drawings to the authority having jurisdiction where required for their approval as required.

### PART 3 – EXECUTION:

- 3.1 Provide all shops in electronic/PDF format. The Engineer's comments will be returned in electronic format.
- 3.2 Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.
- 3.3 Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.
- 3.4 All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.

- 3.5 The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.
- 3.6 It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.
- 3.7 Prior to ordering any materials or rough-in of any kind, the HVAC Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Construction Manager, Mechanical Contractor, Electrical Contractor and their sub-contractors.
- 3.8 Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.
- 3.9 If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.
- 3.10 Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.
- 3.11 All submittals for HVAC equipment shall include all information specified and scheduled. This shall include air and water pressure drops, RPM, noise data, face velocities, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.
- 3.12 All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.
- 3.13 Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

END OF SECTION 230502.

## SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. VARIABLE FREQUENCY MOTOR CONTROL
  - 3. HYDRONIC PUMPS
  - 4. DEDICATED OUTDOOR-AIR UNITS
  - 5. WATER-SOURCE UNITARY HEAT PUMPS

#### 1.2 SCOPE

- A. Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.
- B. Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, General Contractor, Mechanical Contractor, Electrical Contractor and their sub-contractors.

### PART 2 – PRODUCTS:

#### 2.1 MOTORS

- A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications and drawing schedules.
- B. Provide shaft grounding rings for all VFD driven motors.
- C. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
- D. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
- E. Motors shall be capable of frequency of starts as indicated by automatic control system and not less than five (5) evenly time spaced starts per hour for manually controlled motors.

- F. Motors shall have a 1.15 service factor for poly-phase motors and 1.35 service factor for single phase motors.
- G. Motors shall have a temperature rating for 40 deg C ambient environment with maximum 90 deg C temperature rise for continuous duty at full load with 1.15 service factor and Class B insulation.
- H. Unless otherwise noted or required by application, motors shall conform to NEMA Standard MG 1 (Table 12-10) for general purpose, continuous duty, horizontal, T-frame, single speed, design "A" or "B". Utilize design "C" motors where required for high starting torque.
- I. Motor frames shall be NEMA Standard No. 48 or 56. Use driven equipment (fans, pumps, etc.) manufacturer's standards to suit specific application.
- J. Provide inverter rated motors where variable frequency drives are utilized. Motor shall be premium efficiency type with Class F insulation and shall conform to NEMA MG 1 parts 30 and 31. Inverter duty rated motors shall have a temperature rating for 40 deg C ambient environment with maximum of 105 deg C temperature rise.
- K. Motor bearings shall be ball or roller bearings with inner and outer shaft seals. Bearings shall be re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance. Bearings shall be designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
- L. Motor enclosure type shall be open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation. Enclosures shall be guarded drip-proof type motors where exposed to contact by employees or building occupants. Enclosure shall be weather protected Type I for outdoor use or Type II where not housed.
- M. Provide built-in thermal overload protection and, where required, internal sensing device suitable for signaling and stopping motor at starter.
- N. Provide energy efficient motors with a minimum EPACT efficiency in accordance with 10 CFR Part 431 published by the US Dept of Energy (Subpart B Electric Motors and Subpart X Small Electric Motors) as defined by NEMA MG 1, Table 12-10 for 1800 rpm, enclosed motors. If efficiency not specified, motors shall have a minimum efficiency as listed below:

|                |                |               |
|----------------|----------------|---------------|
| 1 hp - 82.5%   | 7.5 hp - 89.5% | 30 hp - 92.4% |
| 1.5 hp - 84.0% | 10 hp - 89.5%  | 40 hp - 93%   |
| 2 hp - 84%     | 15 hp - 91%    | 50 hp - 93%   |
| 3 hp - 87.5%   | 20 hp - 91%    | 60 hp - 93.6% |
| 5 hp - 87.5%   | 25 hp - 92.4%  | 75 hp - 94.1% |
- O. On the motor nameplate, indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

## 2.2 MOTOR STARTERS

- A. Provide motor starters where indicated on the mechanical equipment schedules or elsewhere in the Contract Documents.



- B. Motor starters shall be NEMA style. Their sizing and installation shall be coordinated with the equipment manufacturer's requirements and in accordance with the National Electrical Code.
- C. All starters shall be size 0 minimum. They shall be constructed and tested in accord with latest edition of NEMA standards. All starters shall be across-the-line magnetic type, unless indicated otherwise. On motors of 20 H.P. or greater rating, the supplier shall provide starters capable of limiting inrush currents. These shall be the reduced voltage open-transition type. Do not utilize closed transition starters unless specifically indicated.
- D. Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See remaining paragraphs of the Part and mechanical schedules for further requirements.
- E. Contacts shall be silver-alloy, double-break type except NEMA size 8 and 9 shall be single-break type. Contacts shall be replaceable without removal of wiring or removal of starter from enclosure. Number of contacts shall be as required for service indicated. Contacts shall be gravity dropout type, positive operation.
- F. Coil voltage shall be 120 volts, A.C., 60 HZ or less, as required to suit control systems available voltages. Coils shall be of molded construction, except for size 8 and 9 which shall be hand wound. Provide coil clearing contact as required.
- G. Provide control transformer of adequate K.V.A. as required on all starters with line-to-line voltages higher than 120 volts A.C. Provide fuse block and slow-blow fuse to protect control transformer per NEMA, N.E.C. and U.L.
- H. Provide hand-off-auto selector switch in face of starter, wired into hand and off switch positions. Auto position (if needed) to be field wired as indicated for automatic control.
- I. Provide NEMA Class 20 resetable overload relays, accurately sized to the motor nameplate rating of the motor served and the temperature differential between motor and controller. Overloads shall be easily replaceable, and resetable without opening enclosure, via a push button or similar means. Class 10 or Class 30 overloads may be used depending on type of motor duty encountered.
- J. Provide at least one N.O. auxiliary contact (field-convertible to N.C. operation) with each starter. All starters shall have space for two additional single-pole contacts.
- K. All starters shall be thru-wiring type.
- L. Provide phase failure sensing relay to open starter coil circuit (on loss of one or more phases) on all three-phase starters controlling motors of 7½ H.P. or larger.

## 2.3 ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

- A. All mechanical equipment shall be provided for single point electrical connection unless noted otherwise.

- B. The equipment manufacturer shall provide internally mounted fuses with the equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends or requires fuse protection.) See also, National Electrical Code, Article 440, Part C, and other applicable sections of the N.E.C.
- C. It shall be the Contractor's responsibility to assure that all mechanical equipment requiring electrical connections be provided with all required proper wiring, electrical protective devices, disconnecting means and electro-mechanical starting units to properly match the mechanical equipment requirement.
- D. Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per Code and Project requirements.
- E. Refrigeration condensing units with internal compressors shall be furnished with integral starter.
- F. All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of this Contractor.
- G. All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.
- H. Observe the following standards for manufacture of equipment and in selection of components: (1) Starters, control devices and assemblies - NEMA (I.E.C. style not acceptable), (2) Enclosures for electrical equipment – NEMA, (3) Enclosed switches – NEMA, (4) All electrical work, generally NFPA 70, (5) All electrical work in industrial occupancies - J.I.C. standards, (6) All electrical components and materials - U.L. listing required.
- I. Where scheduled on the drawings, provide disconnect switches and contactors. Disconnect switches shall be fusible type or circuit breaker type.

#### 2.4 REQUIREMENTS FOR HVAC EQUIPMENT 3/4 H.P. OR LESS

- A. This section describes requirements for small mechanical equipment such as (but not limited to) package terminal heating/cooling units, VAV boxes, unit heaters, unit ventilators, exhaust fans, fans, fan coil units, cabinet heaters, DDC temperature control panels, etc.
- B. Small equipment with motor(s) of 3/4 H.P., single phase or less are generally not required to be furnished with starter(s), unless otherwise noted. For such equipment, provide integral contactor or horsepower-rated relay where controlled by thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment.
- C. Provide transformer within unit as required to provide low voltage A.C. for thermostat control.
- D. Provide internal fusing for unit motor and other loads in fuse block or in-line fuse holder.

- E. Where externally-mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction.

PART 3 – EXECUTION: (NOT APPLICABLE)

END OF SECTION 230513

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## SECTION 230517 – SLEEVING AND SLEEVE SEALS FOR HVAC PIPING

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. HVAC PIPING INSULATION
  - 2. HYDRONIC PIPING

#### 1.2 SCOPE

- A. The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.
- B. All work improperly performed or not performed as required in this section, shall be corrected by the General Contractor at the responsible Contractor's expense.

### PART 2 – PRODUCTS:

#### 2.1 SLEEVES

- A. In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation. Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

#### 2.2 FIRESTOPPING

- A. Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.
- B. The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
  - 1. One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
  - 2. One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
  - 3. One hour fire rated gypsum wallboard - 3M #5300-MPC7.
  - 4. Two hour fire rated gypsum wallboard - 3M #5300-MPC7.

- C. The following indicates the 3M penetration details for insulated pipe penetrations of various wall and floor construction types (the list is not inclusive):
1. One, two and three hour fire rated concrete floor - 3M #5300-IMP2.
  2. One, two and three hour concrete block wall - 3M #5300-IMP2.
  3. One hour fire rated gypsum wallboard - 3M #5300-IMP4.
  4. Two hour fire rated gypsum wallboard - 3M #IMP7.
- D. Refer to 07 84 13 for additional manufacturers.
- E. HVAC ducts penetrating a one or two hour fire rated wall or floor shall be firestopped per 3M #5300-HVD1.

### PART 3 – EXECUTION:

- 3.1 The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.
- 3.2 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.
- 3.3 The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.
- 3.4 CUTTING
- A. All openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, or angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor and ceiling finishes as well as to provide a fastening means for devices, etc.
- B. The Mechanical Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, exhaust fans, etc. Prime paint all lintels. Lintels shall be sized as follows:
- C. New Openings under 48" in width: Provide one 3½"x3½"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.
- D. New Openings over 48" in width: Consult with Structural Engineer.

- E. No cutting shall be performed at location that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.
- F. Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe-cut with a masonry saw.

### 3.5 PATCHING, REPAIRING AND FINISHING

- A. Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer.
- B. Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed by the contractor of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.
- C. Piping and ductwork passing through floors, ceilings and walls in finished areas shall be fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.
- D. Flanged metal collars shall be provided around all ducts, flues, pipes, etc. at all wall penetrations; both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2" in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

### 3.6 FIRESTOPPING

- A. Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the authority having jurisdiction if required.
- B. All mechanical pipes and ducts penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed.
- C. Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material and properly sealed to maintain the rating integrity of the wall, floor or ceilings affected.
- D. Where the installation of ductwork requires the penetration of non-rated floors, the space around the duct or pipe shall be tightly filled with an approved non-combustible material.
- E. The manufacturer of the firestopping materials shall provide on site training for the installing Contractor. The training session shall demonstrate to the Contractor the proper installation techniques for all the firestopping materials.

- F. Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit details for specific applications if this method of firestopping is chosen.

END OF SECTION 230517



## SECTION 230553 - IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. DUCT INSULATION.
  - 2. HVAC PIPING INSULATION
  - 3. VARIABLE FREQUENCY MOTOR CONTROL
  - 4. HYDRONIC PUMPS
  - 5. DEDICATED OUTDOOR-AIR UNITS
  - 6. WATER-SOURCE UNITARY HEAT PUMPS

### PART 2 – PRODUCTS:

- 2.1 Provide and install on each valve 1" in size or greater for all mechanical systems a 1.5" diameter circular bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with sequential number identifiers. Number identifiers shall be determined by the Contractor sequentially.
- 2.2 Provide typewritten valve charts indicating each valve identifier, the valves service, normal position and its location. Also furnish one electronic copy on CD in "\*.xls" format. One (1) copy of this chart shall be mounted in suitable frame(s) with clear plastic covers in a conspicuous location in each of the major mechanical rooms. Repeat only main valves which are to be operated in conjunction with operations of more than single mechanical room.
- 2.3 All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified as any valve whose closure could create an emergency condition in the facility (i.e. main HVAC valves, etc.).
- 2.4 Label all control panels and disconnect switches with service and equipment served.
- 2.5 PIPING AND DUCTWORK IDENTIFICATION:
  - A. All piping and ductwork installed shall be identified according to the charts hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping and ductwork installed under this contract. Markers and arrows shall be painted on the piping and ductwork using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. Piping and ductwork shall be identified on twelve (12) foot centers. All piping and ductwork shall be minimally identified once above all room ceilings and where it passes thru walls or floors. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking.

- B. The following table describes the size of the color field and size of the identification letters which shall be used for pipes of different outside pipe diameters.

| Outside Label |        | Letter |
|---------------|--------|--------|
| Diameter      | Length | Size   |
| 3/4" – 1 1/4" | 8"     | 1/2"   |
| 1 1/2" – 2"   | 8"     | 3/4"   |
| 2 1/2" – 6"   | 12"    | 1 1/4" |
| 8" – 10"      | 24"    | 2 1/2" |

- C. The following chart describes the pipe service and label identification which shall be used for various pipes.

| PIPE                       | ABBREVIATION |
|----------------------------|--------------|
| a. Geothermal Supply       | G.S.         |
| b. Geothermal Return       | G.R.         |
| c. Dual Temperature Supply | D.T.S.       |
| d. Dual Temperature Return | D.T.R.       |
| e. Refrigerant Piping      | RF           |
| f. Condensate              | C.D.         |

## 2.6 EQUIPMENT IDENTIFICATION

- A. Unless otherwise specified, all equipment shall be identified. The titles shall be short and concise and abbreviations may be used as long as the meaning is clear. In finished rooms and mechanical rooms, equipment shall be identified neatly and conspicuously with engraved black lamacoid plates (or equivalent) with 1" high white letters on the front of each piece of equipment.
- B. All mechanical equipment and associated starters/disconnects shall have the electrical panel number and circuit number identified on a lamacoid plate. Coordinate with the Electrical Contractor.

## PART 3 – EXECUTION:

- 3.1 All ductwork shall be identified as to the service of the duct and direction of flow. Include equipment designator on SA & RA ductwork. The letters shall be at least two inches high and the flow arrow shall be at least six inches long. The letters and flow arrow shall be made by precut stencils and black oil base paint with aerosol can. Concealed ducts also need to be identified.

| DUCTWORK              | ABBREVIATION              |
|-----------------------|---------------------------|
| Supply Air Ductwork   | SA + Equipment Identifier |
| Return Air Ductwork   | RA + Equipment Identifier |
| Exhaust Air Ductwork  | EA + Equipment Identifier |
| Outside Air Ductwork  | OA + Equipment Identifier |
| Transfer Air Ductwork | TA + Equipment Identifier |

- 3.3 ACCESS THROUGH LAY-IN CEILINGS: Mark each lay-in ceiling panel which is nearest access to equipment, valves, dampers, filters, duct heaters, etc., with colored tape labels located on the ceiling grid.

END OF SECTION 230533

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## SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. METERS AND GAGES FOR HVAC PIPING
  - 3. INSTRUMENTATION AND CONTROL FOR HVAC
  - 4. FACILITY MONITORING SYSTEM
  - 5. VARIABLE FREQUENCY MOTOR CONTROL
  - 6. HYDRONIC PUMPS
  - 7. METAL DUCTS
  - 8. DEDICATED OUTDOOR-AIR UNITS
  - 9. WATER-SOURCE UNITARY HEAT PUMPS

#### 1.2 SCOPE OF WORK

- A. The Engineer, or authorized representative, shall be notified by the Contractor twenty-four (24) hours in advance of any tests called for in these Specifications or required by others.
- B. Only after written approval, signed by the Engineer, shall the Contractor apply insulation or paint or allow the work to be furred-in. This written approval, however, does not relieve the Contractor of the responsibilities for any failure during the guarantee period. The expense of all tests shall be borne by the Contractor, along with all temporary equipment, materials, gauges, etc. required for tests.
- C. The test and balance of this system shall be by a Contractor who employs only the services of a certified AABC or independent NEBB firm whose sole business is to perform test and balance services.
- D. The test and balance contractor shall bid directly to the HVAC Contractor or Construction Manager or Owner.
- E. For the purpose of placing the Heating, Ventilating and Air Conditioning systems in operation according to design conditions and certifying same, final testing and balancing shall be performed in complete accordance with AABC Standards for Total System Balance, Volume Six (2002), for air and hydronic systems as published by the Associated Air Balance Council.
- F. Instruments used for testing and balancing of air and hydronic systems shall have been calibrated within a period of six months prior to balancing. All final test analysis reports shall include a letter of certification listing instrumentation used and last date of calibration.

PART 2 – PRODUCTS: (NOT USED)

PART 3 –EXECUTION

3.1 THE FOLLOWING SYSTEMS SHALL BE TESTED AND BALANCED:

- A. The supply, return, outside and exhaust air duct systems associated with all DOAS and heat pump units. Provide static pressure profiles thru DOAS systems. Static pressure profiles shall include all sections from the return duct inlet and supply duct outlet of the heat pump unit. Show accurate representation of outdoor and exhaust air damper locations.
- B. Toilet exhaust air in each room to within 10% of design air flow rate.
- C. Verify calibrations of the duct static pressure and water pressure sensors for all systems.
- D. Balance all supply and outside, exhaust and return air grilles to within 10% of design air flow rate.
- E. Each DOAS shall have supply and return duct air leakage testing per Specification Section METAL DUCTS. Coordinate with sheet metal contractor.

3.2 Three (3) copies of the complete test reports shall be submitted to the Consulting Engineer prior to final acceptance of the project. Preliminary test reports shall be submitted when requested.

3.3 HVAC Contractor shall provide all start-up documents to Test and Balance Contractor prior to any test and balance services.

3.4 The HVAC Contractor shall test all piping before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory. Water piping systems shall be subjected to a hydrostatic test as specified and shall be proven tight after a twenty-four (24) hour test.

3.5 All motors, bearings, etc. shall be checked and lubricated as required during start-up procedures. All automatic, pressure regulating and control valves shall be adjusted. Excessive noise or vibration shall be eliminated.

3.6 System balancing, where required, shall be performed only by persons skilled in this work. The system shall be balanced as often as necessary to obtain desired system operation and results.

3.7 Testing shall occur after completion of the ceiling systems installation.

3.8 All deficiencies observed by the Test and Balance Contractor shall be reported immediately to the Engineer and Mechanical Contractor.

3.9 Provide a preliminary test report to the Engineer immediately after the system is air balanced, or any initial phases are balanced. This report may be hand written. Any systems that are not found to operate within the design tolerances by the Test and Balance Contractor shall be immediately be reported to the Engineer via telephone call to attempt to determine a resolution while the Test and Balance Contractor is still on site. Additional compensation will not be accepted for additional trips.

- 3.10 Anticipate visiting the site again after the Engineer has reviewed the report. The Engineer may request up to two (2) additional site visits for onsite troubleshooting where additional measurements may be required.
- 3.11 Balance all units rated for 2,000 cfm unit such that the total air volume delivered does not exceed 2,000 cfm, otherwise the Contractor shall furnish and install a code compliant duct smoke detection system integrated into the building's system.
- 3.12 Test and Balance agency shall provide sizing of fan or motor sheaves required for proper balance. The Mechanical Contractor shall purchase and install all sheaves and belts as required. This includes new and existing equipment.
- 3.13 The Contractor shall provide and coordinate work to provide sufficient time before final completion date so that tests and balancing can be accomplished and provide immediate labor and tools to make corrections when required without undue delay.
- 3.14 The Contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.
- 3.15 The Test and Balance Contractor shall be present during the Engineer's final inspection of the building, or a separate project review date. The Engineer may request confirmation of the air balance report by asking for new measurements to be taken at that time. Any information in the test and balance report may be asked to be reconfirmed.

END OF SECTION 230593

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## SECTION 230713 - DUCT INSULATION

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
  - 3. METAL DUCTS
  - 4. AIR DUCT ACCESSORIES
  - 5. DIFFUSERS, REGISTERS & GRILLES

#### 1.2 SCOPE OF WORK

- A. Work under this section shall include all labor, equipment, accessories, materials and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.
- B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.
- C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.
- D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.
- E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.
- F. "Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Ductwork in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".
- G. The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

### 1.3 FIRE RATINGS AND STANDARDS:

- A. Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50 and Fuel Contributed 50.
- B. All products and their packaging shall bear a label indicating above requirements are not exceeded.
- C. Fiber glass duct wrap shall meet the requirements of Scientific Certification Systems Certification or Greenguard Validation of Formaldehyde Free.
- D. Fiber glass mechanical board shall meet the requirement of the Greenguard Standards for Low-Emitting Products.
- E. Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

### PART 2 – PRODUCTS:

- 2.1 ACCEPTABLE MANUFACTURERS: Johns Manville, Knauf, Owens-Corning.
- 2.2 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.
- 2.3 EXTERNAL INSULATION FOR SUPPLY AIR: Knauf "Friendly Feel" faced, Duct Wrap, 0.75 PCF density, 2.2" thick or approved equivalent. Wrap shall be factory laminated to a reinforced foil kraft vapor barrier facing (FRK) with a 2" stapling flange at one edge. The installed R value shall be a minimum of 6.0. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch.
- 2.4 EXTERNAL INSULATION FOR LOUVER PLENUMS AND OA/EA DUCTWORK FROM LOUVER TO DOAS: Knauf "Insulation Board" or approved equivalent industrial insulation. Use 1½" rigid fiberglass industrial board with foil scrim kraft vapor barrier facing, 6.0 PCF density,  $K=0.22 \text{ Btu in./hr.ft}^2 \text{ }^{\circ}\text{F @ } 75^{\circ}\text{F}$ . Use 1/2" thick, 1.6 PCF insulation board for round ducts. The installed R-value shall be a minimum of 6.0. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch. Provide 6oz. canvas jacket with fire retardant lagging and provide a metal corner bead at all duct corners (on the exterior of the insulation) for protection. The corner bead shall be taped in place with foil scrim tape.
- 2.5 INTERNAL INSULATION: Where noted on the drawings, duct liner shall be 1" thick flexible elastomeric insulation (Armaflex AP Duct Liner).  $K=0.27 \text{ BTU in./hr. ft}^2 \text{ }^{\circ}\text{F @ } 75^{\circ}\text{F}$ .
- 2.6 DUCT SOUND ABSORBER / DUCTWRAP: Where noted on the drawings, in addition to the duct insulation specified, install 1" thick Kinetics KBC-100RBQ (or Sound Seal BBC-1 B-10FS QFA-1) limp barrier material (1.3 lb./sq ft), reinforced with a fiber glass screen, loaded with barium sulphate, with a quilt faced fiber glass absorber on one side. Install per manufacturer's instructions. Minimum sound transmission loss per octave band shall be 125Hz-10dB/250Hz-16dB/500 Hz-22dB/1000Hz-30dB/2000Hz-39dB/4000Hz-43dB/STC-27. Provide steel banding to ensure restraint of duct wrap.

PART 3 – EXECUTION:

- 3.1 The Contractor shall photograph any installations prior to concealment.
- 3.2 Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to ductwork until tested, inspected and released for insulation.
- 3.3 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.
- 3.4 Duct insulation shall extend completely to all registers, grilles, and diffusers outlets, etc., to insure no condensation drip or collection.
- 3.5 All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered ductwork is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.
- 3.6 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.
- 3.7 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!
- 3.8 All insulation shall be installed with joints butted firmly together.
- 3.9 The Contractor shall insure that all duct insulation is completely continuous along all conduits, equipment, connection routes, etc. carrying cold (air) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

END OF SECTION 230713

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## SECTION 230719 - HVAC PIPING INSULATION

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. METERS AND GAGES FOR HVAC PIPING
  - 3. GENERAL DUTY VALVES FOR HVAC PIPING
  - 4. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
  - 5. HVAC PIPING INSULATION
  - 6. INSTRUMENTATION AND CONTROL FOR HVAC
  - 7. FACILITY MONITORING SYSTEM
  - 8. HYDRONIC PIPING
  - 9. HYDRONIC PUMPS

#### 1.2 SCOPE

- A. Work under this section shall include all labor, equipment, accessories, materials and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.
- B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.
- C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.
- D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.
- E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.
- F. "Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Piping in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".
- G. The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

### 1.3 FIRE RATINGS AND STANDARDS:

- A. Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50 and Fuel Contributed 50.
- B. All products and their packaging shall bear a label indicating above requirements are not exceeded.
- C. Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

### PART 2 – PRODUCTS:

- 2.1 ACCEPTABLE MANUFACTURERS: Johns Manville, Knauf, Owens-Corning.
- 2.2 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.
- 2.3 EXPOSED, INTERIOR (INTERIOR FINISHED ROOMS, STORAGE ROOMS, ETC.) JACKETS: All insulated items installed in the above areas shall have a 6 oz. canvas jacket with fire retardant lagging apply to the insulation specified for the piping.
- 2.4 PIPE INSULATION MATERIAL: Insulation shall be Knauf "Earthwool 1000° Pipe Insulation ASJ+/SSL+" or approved equivalent fiberglass pipe insulation with an all-service jacket. The insulation shall be a heavy density, pipe insulation with a K factor not exceeding 0.27 Btu per inch/h.ft<sup>2</sup> °F at 75°F mean temperature. The insulation shall be wrapped with a vapor barrier jacket. The jacket shall have an inside foil surface with self sealing lap and a water vapor permeability of 0.02 perm/inch. All circumferential joints shall be vapor sealed with butt strips. All insulation shall be installed in strict accordance with the manufacturer's recommendations. The following pipes shall be insulated with the minimum thickness of insulation as noted.
  - A. Dual Temperature Hydronic Water: 1-1/2" thick insulation
  - B. Refrigerant Suction Lines: 1/2" thick elastomeric insulation
  - C. Geothermal Heat Pump Piping: 1" thick (Not required for HDPE piping exposed on mechanical mezzanines / rooms over concrete floor,). Any piping above or over a ceiling or concealed shall be insulated.
  - D. Condensate Drain Lines: 1/2" thick (Not required for PVC piping exposed on mezzanines over concrete floor). Any piping above or over a ceiling or concealed shall be insulated.
  - E. HVAC Fill Lines: 1" thick insulation

### PART 3 – EXECUTION:

- 3.1 The Contractor shall photograph any installations prior to concealment. This includes risers in chases and at rooftop equipment.

- 3.2 Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping, until tested, inspected and released for insulation.
- 3.3 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.
- 3.4 All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.
- 3.5 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.
- 3.6 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!
- 3.7 All insulation shall be installed with joints butted firmly together.
- 3.8 The Contractor shall ensure that all piping insulation is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (water, refrigerant, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.
- 3.9 Seal insulation and jacket at all points where insulation terminates at unions, flanges, valves and equipment. This applies to hot water lines only as cold water lines require continuous insulation and vapor barrier.
- 3.10 Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over pumps, etc. to insure no condensation drip or collection.
- 3.11 Valves, flanges and unions shall only be insulated when installed on cold fluid piping whose surface temperature will be at or below the dew point temperature of the ambient air.
- 3.12 Insulation shall not extend through fire and smoke walls. Pack sleeve at fire and smoke wall with approved fire retardant packing similar to mineral wool and seal with approved sealant.
- 3.13 Metal insulation shields and inserts are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180 degree arc. Insulation shields shall be the following size:

| Pipe Size   | Shield Gauge | Shield Length |
|-------------|--------------|---------------|
| 2" and less | 20           | 12"           |
| 2 ½" - 4"   | 18           | 12"           |
| 5" - 10"    | 16           | 18"           |

- 3.14 Insulated pipes 2" in diameter and larger shall be additionally supported with wood inserts of sufficient compressive strength to carry the weight of the pipe and fluid. Inserts shall extend beyond the hanger and shall be at least 6" in length.
- 3.15 Provide premolded PVC insulated fitting covers on all pipe fittings, flanges, valves and pipe terminations. Fittings shall be insulated by applying the proper factory precut insulation insert to the pipe fitting. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipe fitting. The proper thickness of insulation must be applied to keep the jacket temperature less than 150°F. An approved vapor retarder mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover shall then be applied and secured with pressure sensitive tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side. On fittings where the operating temperature is below 50°F, two or more layers of the insulation inserts shall be applied with the first layer being secured with a few wrappings of fiber glass yarn to eliminate voids. One additional insert shall be used for each additional 1" of pipe insulation above 1-1/2". All joints shall be fully sealed.

END OF SECTION 230719



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## SECTION 238000 – COMMISSIONING – MECHANICAL

### PART 1 – GENERAL:

#### 1.1 RELATED SECTIONS:

- 1.1.1 Division 1 – General
- 1.1.2 Division 22 - Plumbing
- 1.1.3 Division 23 - Mechanical
- 1.1.4 Division 26 – Electrical

#### 1.2 REFERENCES

- 1.2.1 Drawings and general provisions of contract, including general and supplementary conditions, general mechanical provisions and Division-1 Specification sections, apply to work of this section.
- 1.2.2 ASHRAE Guideline 1-1996
- 1.2.3 ASHRAE Guideline 0-2005
- 1.2.4 ACG Commissioning Guideline – 2005

#### 1.2 DESCRIPTION OF WORK

- 1.2.1 The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the mechanical systems have been installed in the prescribed manner, and operate within the performance guidelines set in the Basis of Design Documents (BOD). The CA shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The CA will be a member of the construction team, administrating and coordinating commissioning activities with the design team, General Contractor, subcontractors, manufacturers and equipment suppliers.
- 1.2.2 The independent commissioning agent (CA) contracted directly with the owner for this project. This specification has been included for reference only to define contractors' responsibilities. Each contractor should review this procedure and include adequate time in their proposal.

### PART 2 - PRODUCTS

- 2.1 Not used.

### PART 3 - EXECUTION

#### 3.1 ROLES OF THE COMMISSIONING AGENCY

- 3.1.1 The primary point of responsibility is to inform the General Contractor, the owner and design team on the status, integration, and performance of HVAC systems within the facility.
- 3.1.2 The CA shall function as a catalyst and initiator to disseminate information and assist the design and construction teams in implementing completion of the construction process. This shall include system verification, functional performance testing, and conformance with the intended design of each system. Services include documenting construction observations, verification and functional performance testing, and documenting proper distribution of performance and operating information to the owner's O&M staff.
- 3.1.3 Assist the responsible parties to maintain a high quality level of installation by meeting or exceeding prevailing standards and specifications.
- 3.1.4 The CA shall observe and coordinate testing as required to assure system performance meets the design intent.
- 3.1.5 The CA shall document the results of the performance testing directly and/or assure that the appropriate technicians document testing. The CA shall approve standard forms to be used by all parties for consistency of approach and type of information to be recorded.
- 3.1.6 The CA shall provide technical expertise to oversee and verify the correction of deficiencies found during the commissioning process.
- 3.1.7 The CA is to remain an independent party with specific knowledge of the project. The CA shall investigate the scope and extent of the problem and facilitate communication to determine responsibilities by delineating specifications. The CA shall monitor resolution for conformance with design intent and prevailing industry standards.
- 3.1.8 The CA shall document the date of acceptance as determined by the General Contractor, owner and design team. System Verification Checklists and Functional Performance Test results may be used in determining the start of the warranty period for HVAC systems and subsystems.
- 3.1.9 The CA will review operating and maintenance materials for HVAC systems.
- 3.1.10 The CA will review phasing plans as provided by the CM relating to temporary use of HVAC equipment, O&M considerations, warranty issues, impact of construction sequencing on occupied areas, and interruption of services from the existing equipment.
- 3.2 SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS
- Dedicated Outdoor Air Units
  - Geothermal Heat Pumps
  - Exhaust Fans
  - DDC Control System
  - VAV Terminal Units
  - Hydronic Water Pumps

### 3.3 HVAC COMMISSIONING PLAN

3.3.1 Commissioning Team: The Commissioning Team (CT) shall consist of key parties involved in design, construction and testing of this facility. It is necessary for each agency to appoint team members that will have long-term commitments to this project. Switching team members during the project will reduce the ability of the CT to provide continuity and acceptable results to the building owner. Team members must maintain an ongoing supervisory position on this project. One team member shall be provided by each of the parties listed below:

- Program Manager (PrM)
- Facilities Management Division (FMD)
- Commissioning Agent (CA)
- Design Team (DT)
- General Contractor (GC)
- Mechanical Contractor (MC)
- Controls Contractor (CC)
- Test and Balance Contractor (TABC)
- Electrical Contractor (EC)

#### 3.3.2 Basis of Design Document

- The Basis of Design Document (BOD) represents a composite of design drawings, project specifications, submittals, change orders and industry standards that describe the systems of this facility. References to design intent will be taken from these contract documents. The BOD is an evolving manuscript maintained by the design professional to track and incorporate design alterations that occur throughout the construction process. Any industry standards used for this project will be specifically noted when referenced.
- The CA will review the BOD documents for adequate commissioning provisions, functional performance, optimization of performance, accessibility, TAB provisions, and O&M considerations.

#### 3.3.3 Commissioning Meetings

- Commissioning meetings will be held in conjunction with progress meetings as necessary. The CA will be on site for the CX meetings. Commissioning meetings will be used to address any problems that alter the design intent or affect the commissioning process. These meetings provide an open forum for exchange of ideas between contractors, vendors, designers, users and owners.

#### 3.3.4 Resolution Tracking Forms (RTF)

- The use of Resolution Tracking Forms is a method employed by the CA to monitor and record problems, their causes, and solutions. The use of these lists promotes communication between the installing contractors, design team, commissioning agent, and owner, in order to expedite their resolution in a timely manner.
- The CA will regularly submit RTF's to the CT in order to document and resolve deficiencies as quickly as possible. The frequency of RTF submission will be adjusted as project conditions dictate.

#### 3.3.5 System Verification Checklists (SVC) / Manufacturers' Checklists

- The MC will provide SVC's based on manufacturers start-up procedures. These tests should be provided for all systems and subsystems. See *SYSTEMS INCLUDED IN THE*

*COMMISSIONING PROCESS.* Draft copies will be submitted to the CT for review and comment prior to placement on the job site. A master copy of the SVC's will be bound in a three-ring binder and placed on the job site for use by the installing contractors. No system will be started until the appropriate SVC's have been completed.

- The CA will review the SVC for each piece of equipment prior to start-up. Equipment will be released for start-up only after these checklists have been completed by the installing contractor and reviewed by the CA.
- The equipment manufacturers' checklists must also be reviewed by the CA prior to start-up. These lists must be completed by the installing contractor, and reviewed by the CA before start-up can commence.

### 3.3.6 Start-Up

- Start-up of major HVAC systems will be witnessed the CA. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate SVC's have been completed. No system will be started until the Manufacturer's checklists have been completed. Start-up will be performed according to the Manufacturer's recommended procedures. The CA will visit the site to review completeness of installation in conjunction with progress meetings prior to starting HVAC equipment.
- CT members involved in installation, fabrication, manufacture, control, or design of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the BoD.

### 3.3.7 Controls Monitoring

- Close monitoring of the Control Contractor's progress will promote efficient coordination of the TAB work. The CC will be expected to submit point-to-point checklists verifying that his work has been completed and all systems are ready for TAB work and Functional Performance Testing. Programming and graphics will be surveyed by the CA for completeness and conformance with the BoD and the owner's scheduling requirements.

### 3.3.8 TAB Monitoring

- The preliminary TAB report set-up will be reviewed prior to HVAC equipment start-up, in order to assure that the final TAB report format and content is acceptable.
- TAB work will be monitored so that any problems that prevent or hinder proper air and water balance can be addressed and corrected with minimal delays. By addressing these problems as quickly as possible, we can assure that functional performance testing and owner training will take place on schedule.
- A pencil copy of the TAB report will be reviewed prior to submission of the final TAB report. A written review will be submitted to the TAB contractor and to the DT for their comments. A TAB report approved by the DT will be required before Functional Performance Testing can be carried out. The CA will visit the site during the TAB process in order to assist TABC and CC in the effective completion of their scope of work.

### 3.3.9 Functional Performance Tests (FPT)

- 3.3.9.1 The CA will write FPT's based on the respective sequence of operations. These tests will be created for systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS* above.
- 3.3.9.2 Each major system will be tested. A random sample of each subsystem will be tested. This will be coordinated and witnessed by the CA and the owner's maintenance staff. Witnessing the FPT's will serve as a compliment to the O&M Training. No FPT's will be performed until the system and related subsystems have been started, the TAB report has been submitted and reviewed, and the completion of the control system has been documented through point-to-point checklists and other documentation.
- 3.3.9.3 The Functional Performance Tests shall include HVAC and related equipment.
- The outside air unit will be tested in designed operating modes. Proper operation will be verified at minimum OA, maximum OA, automatic control, and other modes, if necessary, to achieve BOD conformance.
  - Variable Air Volume terminals with and without reheats will be tested at minimum and maximum temperature set points, and under automatic control. Intermediate settings will be tested as necessary.
  - Variable refrigerant system will be tested in designed operating modes. Proper operation will be verified at minimum loads, maximum loads, waterside economizing mode, Manual control, automatic control, and other modes.
  - Variable refrigerant heat pump units will be tested under relevant operating conditions.
  - The heat pumps will be tested under relevant operating conditions.
  - EF's will be tested for conformance to BoD.
  - Hydronic pumps will be tested under relevant operating conditions.
  - DDC control systems will be tested as necessary.
  - HVAC systems will be tested to assure that the building as an integrated system operates properly.
  - Trend verification of systems and subsystems shall be completed prior to start of functional performance testing. CA will provide trend format to CC and discuss trend requirements in CX meetings throughout the construction phase of project.
- 3.3.9.4 Deferred Testing
- If tests cannot be completed because of a deficiency outside the scope of the responsible contractor, the deficiencies shall be documented and reported to the Owner. Deficiencies shall be resolved and corrected by the appropriate parties and test rescheduled.
  - Off-season mode testing will be implemented as necessary to assure conformance with the BoD. Installing contractors will be expected to participate as required by the project specifications.
- 3.3.9.5 Rescheduled Functional Performance Test
- During Functional Performance Testing period, it is assumed that the contractors will be complete with all checklists when the commissioning agents travel to site. If the work is not ready for commissioning when the commissioning personnel are on site, their time will be billed to the contractor as an additional fee.
  - If the contractor has deficiencies that cannot be corrected at the time of the test, that part of the sequence will be retested at a later date. If the deficiency does not pass during the retest, the contractor will be billed for the commissioning personnel's return trip.

3.3.10.6 Building Turn-Over / Owner Orientation / User Training

- The CA will oversee contractors prepare, coordinate and review O&M manuals, working closely with each contractor to achieve specificity and completeness.
- The CA will review as-built drawings, working closely with each contractor to achieve specificity and completeness.
- Owner training will be coordinated with the assistance of the CA. The training will be provided by the installing contractor, or manufacturer's representative, and witnessed by the CA. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The CA will visit the site during the Turn-Over and Training period to assure that any on-going HVAC related problems are being addressed and corrected in a timely and efficient manner.
- The CA will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.

3.4 RESPONSIBILITIES OF TEAM MEMBERS

3.4.1 General Contractor (GC)

- Include commissioning requirements in the mechanical, electrical, and controls contracts, as well as other subcontracts, to assure full cooperation of all parties in the HVAC commissioning process.
- Assure acceptable representation, with the means and authority to prepare and coordinate execution of the mechanical commissioning program as described in the contract documents.
- Assure that the CA shall receive a copy of all construction documents, addenda, change orders and appropriate approved submittals and shop drawings for review and use in development of the commissioning plan.
- Coordinate inclusion of commissioning activities in the construction schedule.
- Facilitate resolution of deficiencies identified by observation or performance testing.
- Involve CA in selection of the air balancing contractor.
- Assist the CA in monitoring the duct leakage testing.

3.4.2 Mechanical Contractor (MC)

- Each contractor in this division shall include in their quote the cost of participating in the commissioning process.
- Include requirements for submittal data (including partial load data), O&M data, and training in each purchase order or sub-contract.
- Assure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, water treatment, temperature controls, and TAB in commissioning activities.
- Assure participation of major equipment manufacturers in appropriate startup, training, and testing activities.
- Attend commissioning meetings scheduled by the CA.
- Assist the CA in system verification and performance testing.
- Prepare preliminary schedule for HVAC system inspections, O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, system verification, performance testing, and system completion for use by the CA. Update schedule as appropriate throughout the construction period.
- Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.

- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Notify the CA a minimum of two weeks in advance of scheduled system start-up.
- Update drawings to as-built condition and review with the CA throughout the construction process.
- Schedule vendor and subcontractor provided training sessions as required by project specifications.
- Provide written notification that the following work has been completed in accordance with the project documents and that the equipment, systems and sub-systems are operating in accordance with design intent.
  - HVAC equipment including fans, air handling units, dehumidification units, ductwork, dampers, terminal devices, etc.
  - Fire detection and smoke detection devices furnished under other divisions as they affect the operation of the HVAC systems.
  - That BAS is functioning in accordance with design intent.
- Participate in the Functional Performance Tests.
- Participate in the off-season mode testing.
- Participate in O&M Training as required by project specifications.
- Provide a complete set of as-built drawings and O & M manuals for review. The CA shall review the as-built drawings and O&M manuals concurrently with the design team.

#### 3.4.3 Test and Balance Contractor (TABC)

- Include cost for commissioning requirements (participation) in the contract price.
- Attend commissioning meetings scheduled by the CA.
- Submit the TAB procedures and preliminary TAB report to the CA for review at least two weeks prior to beginning TAB work.
- Notify the CA a minimum of two weeks in advance of scheduled TAB work.
- Provide partial, preliminary TAB Reports by phase, by building section, by system, or as required by the CA.
- Assist the CA in system verification and performance testing.
- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the CA for verification or diagnostic purposes.
- Participate in the Functional Performance Tests as required to achieve design intent.
- Provide sound and vibration where required to assist in diagnosis of areas exhibiting unacceptable levels of noise or vibration.
- Participate in the off-season mode testing as required to achieve design intent.
- Participate in O&M Training as required by project specifications.

#### 3.4.4 Temperature Control Contractor (TCC)

- Include cost for commissioning requirements in the contract price.
- Review control sequence and component selection for conformance with design intent.
  - Attend a submittal review meeting with the CA and Engineer to ensure clear understanding of scope of work and expectations.
  - Verify that specified safeties and interlocks have been selected.
  - Verify proper selection of control valves and actuators based on design parameters.

- Verify proper selection of control dampers and actuators based on design parameters.
  - Verify that sensor selection conforms to design intent.
- Attend commissioning meetings scheduled by the CA.
- Provide the following submittals to the CA:
  - Hardware and software submittals.
  - Control panel construction shop drawings.
  - Narrative description of control sequences for each HVAC system and subsystem.
  - Schematics showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access.
  - A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
  - A complete listing of all software routines employed in operating the control system. Also provide a program narrative that describes the logic flow of the software and the functions of each routine and sub-routine. The narrative should also explain individual math or logic operations that are not clear from reading the software listing.
  - Hardware operation and maintenance manuals.
  - Application software and project applications code manuals.
  - Panel and equipment insert documents.
  - Assist CA with remote monitoring capabilities. Supply any software and/or hardware needed.
- Verify that specified interfaces provided by others are compatible with BAS hardware and software.
- Coordinate installation and programming of BAS with construction and commissioning schedules.
- Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.
- Provide control system technician to assist during equipment startup.
- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Participate in the Functional Performance Tests as required by the project specifications.
- Provide a control system technician to assist during verification and performance testing.
- Provide system modifications to achieve system operation as defined by the design intent.
- Provide support and coordination for TAB contractor. Provide all devices, such as portable operator terminals and all software for the TAB to use in completing TAB procedures.
- Provide written notification that the TCC scope of work has been completed in accordance with the project specifications, and that the equipment, systems and sub-systems are operating in accordance with design intent, and that BAS is functioning in accordance with design intent.
- Participate in the Functional Performance Tests as required to achieve design intent.
- Participate in the off-season mode testing as required to achieve design intent.
- Participate in O&M Training as required by project specifications. Include training on hardware operations and programming

END OF SECTION 230800



## SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. METERS AND GAGES FOR HVAC PIPING
  - 3. FACILITY MONITORING SYSTEM
  - 4. VARIABLE FREQUENCY MOTOR CONTROL
  - 5. HYDRONIC PUMPS
  - 6. DEDICATED OUTDOOR-AIR UNITS
  - 7. WATER-SOURCE UNITARY HEAT PUMPS

#### 1.2 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls. All labor, materials, tools, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned shall be included for the complete, fully functional and commissioned temperature controls system.
- B. The contractor shall provide all items, articles, materials, devices, operations or methods listed, mentioned or scheduled on the drawings including all labor, materials, equipment and incidentals necessary and required for their completion to provide a complete and operating temperature control system. This will include connecting to any mechanical equipment furnished with a control interface device and contacting the equipment suppliers and/or manufacturers for information for the proper interface to the equipment being furnished.
- C. These apparatuses shall consist of, but not limited to, all necessary thermostats, sensing devices, valves, damper motors, actuators, and with the necessary accessories for the complete control of all equipment hereinafter specified.
- D. Control sequences on plans. Provide all control equipment required to perform sequences described. Coordinate all dampers with the sheet metal contractor and equipment provider. It is the responsibility of the control contractor to ensure all required dampers in the sequence of operations are provided.
- E. Include all power wiring and cabling for the operation of the controls system. Refer to Electrical Division Specifications for additional requirements.

- F. APPROVED MANUFACTURER'S: Instruments shall be provided by the Temperature Control Contractor. Refer to FACILITY MONITORING SYSTEM
- G. The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.
- H. ABBREVIATIONS:
1. TCC – Temperature Control Contractor
  2. I/O: Input/output.
  3. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
  4. MS/TP: Master slave/token passing.
  5. PC: Personal computer.
  6. PID: Proportional plus integral plus derivative.
- I. The contractor shall list the following cost breakdowns, material and labor, on the official project schedule of values:
1. Controls shop drawings
  2. Controls graphics
  3. Controls materials and labor
  4. Controls startup, commissioning, testing, documentation (2.5% of controls contract value)
  5. Controls training and Owner acceptance (2.5% of controls contract value)

## PART 2 - PRODUCTS

### 2.1 SENSORS AND MISCELLANEOUS DEVICES

- A. SENSOR RESOLUTION: All temperature sensors shall have a minimum resolution of 1/10th of 1 degree F. (0.1 degree F.) Sensor stability shall be 0.24 degrees over a year period. Space sensors shall be tested and accurate to within 0.75 degrees F. Outside air, water and duct sensors shall be tested and accurate to within 2.0 degrees F.
- B. WATER SENSORS: Temperature sensors for water lines are to be the well type. Wells are to be threaded brass (same manufacturer as the temperature sensor) with the sensor coated with a heat transfer compound. Strap on sensors will not be acceptable.
- C. OUTDOOR AIR SENSOR/ WEATHER STATION HOUSING: Provide Kele Model A21 Outdoor Aspirated Humidity/Temperature housing. NEMA 3R enclosure is painted white to reduce the effect of radiation, and the enclosure has a lockable latch for security. Sensor Accuracy: +/-2 degrees F.
- D. DISCHARGE AIR SENSORS: Shall be rigid insertion type.
- E. FREEZE/LOW-LIMIT THERMOSTAT: Provide a freeze/low-limit thermostat in each Air Handling Unit, Outside Air Unit, etc with a water coil for freeze protection. These devices shall be the manual reset type. This device shall be wired by using a normally closed contact in series with the motor starting circuit and a normally open set of contacts as an input to the unitary

controller. The element shall be constructed of copper and be at least 20 feet in length. The device shall sense the lowest temperature by any one foot section of its element.

- F. COMBINATION TEMPERATURE/HUMIDITY SENSORS: All temperature sensors shall have a minimum resolution of 1/10th of 1 degree F. (0.1 degree F.) Sensor stability shall be 0.24 degrees over a year period. Space sensors shall be tested and accurate to within 0.75 degrees F. The humidity sensing device shall be 100% solid state, linear and temperature compensated with a 0-100% RH range. The response time shall be a minimum of 30 seconds for a 60% change. They shall have a minimum of 2% accuracy minimum accuracy of +/-2% RH minimum rangeability 5 to 95% RH non-condensing and maximum hysteresis +/- 1.5% RH. – Do not submit products that do not meet this range. The output of the device must utilize a 0-10 VDC or 4-20mA signal as required. The device must use a power supply of 24 VAC or VDC. Duct mounted sensors shall have at least 4" insertion probe with a 16-gauge steel enclosure. NIST traceable certification shall be provided to the Engineer as part of the shop drawings. For wall mounted sensors the enclosure shall be polystyrene plastic mounted next to and at the same height as the temperature sensor in that area. Both shall have the same appearance.
- G. LOW PRESSURE TRANSDUCERS: These devices shall be 100% solid state, linear and temperature compensated. Accuracy shall be no less than plus or minus 1% of its full range. Linearity, repeatability and hysteresis shall be no less than plus or minus 0.1%. All pressure sensors shall utilize output averaging/output clipping to adjust and stabilize any fluctuations in the output. The output of the device shall utilize a 0 - 10 VDC signal. The device shall use a power supply of 24 VAC or VDC. The enclosure 16-gauge steel. For sensing internal static pressure of air handling ducts utilize sensors with a range of 0 to 5 inches water column. For sensing building static pressures (building compared to atmospheric) utilize a sensor with a range of -0.25 to +0.25 inches water column.
- H. RELAYS: Relays for starting and stopping fractional horsepower motors shall be rated as follows:
1. 1/4 horsepower motors or less use 15 ampere rated relays,
  2. 1/3 horsepower motors use 20 ampere rated relays,
  3. 1/2 horsepower motors use 30 ampere rated relays,
  4. Relays used for pilot duty service shall be rated at a minimum of 10 amperes.
  5. Provide auxiliary pilot duty relays on motor starters as required for control function.
  6. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.
- I. SMOKE SHUTDOWN: All OA units, Heat Pump Units, etc with fans of greater than 2,000 CFM are required to have smoke shutdown safeties as required by the Building Code. These smoke detectors shall have a set of auxiliary contacts wired to a dedicated input of the Unitary to provide status of the smoke detector. All units must be provided with a current sensor to provide fan status for each air handler. For projects with Outside Air (OA) units, any system fire alarm activation shall shutdown all OA units.
- J. CURRENT SENSING DEVICES: Veris Industries model Hx08 Series and H701 or equal. All current sensors shall be capable of alarming to the BAS for belt losses, pump coupling shear or other mechanical failure on loads.

- K. DIFFERENTIAL PRESSURE TRANSMITTERS: Provide Rosemount (ITT Bell & Gossett ST-102R) or equal field mounted differential pressure sensor transmitters as indicated on the plans. Range shall be 0-25 psig. Accuracy shall be .025% full span.
- L. CARBON DIOXIDE SENSORS: This sensor shall be electronic non-dispersive infrared (NDIR) type, diffusion sampling with LED or LCD display.
1. Measurement Range 0-2000/5000 ppm (programmable)
  2. Accuracy  $\pm 30$  ppm  $\pm 2\%$  of measured value\*
  3. Repeatability  $\pm 20$  ppm  $\pm 1\%$  of measured value
  4. Response Time <60 seconds for 90% step change
  5. Input Power 20 to 30VDC/24VAC; 100mA max.
  6. Analog Output 4-20mA, (clipped & capped)/0-5VDC/0-10VDC (selectable)
  7. Operating Temperature Range 0° to 50°C (32° to 122°F)
  8. 5-year calibration interval (recommended)
  9. Low ambient sensitivity
- M. AIRFLOW MEASURING STATION: Ebtron (or equal) Model P+ GTC116, airflow measurement: Accuracy:  $\pm 2\%$  of reading, Calibrated range: 0 to 5,000 fpm, NIST traceable calibration; Temperature measurement Accuracy:  $\pm 0.15$  deg F, Calibrated range: 20 to 160 deg F, NIST traceable calibration. Coordinate cable length with manufacturer. Two isolated analog output signals (field selectable/scalable 0-5/0-10 VDC or 4-20mA).

## 2.2 VALVES, DAMPERS AND ACTUATORS

- A. Unless otherwise specified, valves shall be furnished and sized by the contractor. The valves are to provide the required capacity and the close off rating shall be in excess of the system pressures encountered (minimum 40 psi differential). Proportioning-type valve bodies shall be packed type with throttling type inner valve (quick close plug shall not be acceptable). Proportional type valves to be rated at 125 psi static pressure. Modulating control valves shall be selected within a 3-5 psig pressure drop range. Two position control valves (open/close) shall be line size.
- B. Dampers for various units requiring field mounting shall be tight closing, "ultra low leakage", opposed blade with side and edge seals. They shall be sized and furnished under this section. Installation of dampers shall be by the sheet metal contractor, coordinated by this contractor. Frames shall be no less than 16 gauge galvanized steel and furnished with mounting holes for duct mounting. Damper blades shall be no less than 14 gauge galvanized steel with maximum blade width of 8 inches. Blades shall be secured to 1/2 inch zinc plated axles and hardware with nylon bearings. Provide thrust bearings at the end of each blade. All dampers shall have end switches to positively prove damper position. No Exceptions!
- C. All damper and valve actuators shall be fail safe spring return type with sufficient force to operate the dampers or valves under all normal operating conditions. They shall return to the normally open position upon a loss of power. Exceptions to the spring return applications are (1) face and bypass actuators. Actuators for terminal units, etc shall fail in the last position.
- D. "ALL" Actuators shall be of the same manufacturer and have internal feedback circuitry to provide a positive action to ensure proper positioning of the damper or valve through the entire sequence. Actuators shall have an adjustable starting point to accurately set the range of travel to the output of the controller. All actuators shall also utilize the same input signal (6-9 VDC, 0-

010V, 2-10 VDC, 4-20 MA) in order to maintain some consistency in the control application. Analog actuation is 6-9 VDC, 0-010V, 2-10 VDC or 4-20 MA, floating point control with 2 digital outputs is NOT approved as analog actuation.

- E. Modulating control valves shall be from the same manufacturer. Actuators used with the valves may be from the vendor of choice provided they are approved for use by the valve manufacturer. The valve actuators shall be capable of opening and closing the valve against the rated shutoff head of the pump(s) serving the loop.
- F. Heat pumps shall have 2-position ball valves. Belimo or approved equal.

### PART 3 – EXECUTION:

- 3.1 A mandatory pre-installation meeting shall occur prior to the contractor beginning any work on site. This meeting shall be attended minimally the prime contractor, mechanical contractor superintendent, contractor superintendent, Engineer, Owner and Architect. The purpose of the meeting is to have the controls installer communicate their understanding of the system design and how the system is intended operate to the Engineer and get the Engineer's input and agreement. The agreement between the contractor and the mechanical engineer is to be thoroughly documented by the contractor for later reference.
- 3.2 The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.
- 3.3 SPACE SENSORS AND THERMOSTATS:
  - 1. Refer to the drawings for proper type and location.
  - 2. Heat Pumps, VRF and VAV Diffuser are shown to be provided with factory thermostats. Refer to plan for equipment and locations to be installed.
  - 3. All thermostat and sensors shall be provided with temperature indication, unless otherwise noted.
  - 4. Programmed set-point shall be locally adjustable limited to 2 degrees above set-point and 2 degrees below set-point for supervised areas.
  - 5. Unsupervised areas shall have non-adjustable set-point.
  - 6. Generally, thermostats/sensors shall be installed 5'-0" above the finished floor.
  - 7. Where thermostats/sensors are to be mounted next to a light switch, install at the same height as the light switch.
  - 8. If there is a question consult engineer prior to rough-in.
- A. OUTDOOR AIR SENSOR: The outdoor air sensor will be installed on the north wall in the shade as not to be affected by sunlight, building ventilation or weather. If not installed to provide "accurate" temperature it must be relocated (at the temperature control contractors expense) until such a location is found. Installation in outside air ductwork or louvers is not acceptable. This location must be indicated on the control drawings. There will be no exceptions to this unless approved by the consulting engineer and owner. The OAT sensor shall be wired directly to the heating system controller. If not installed to provide "accurate" temperature readings, it shall be relocated until a suitable location is found.

- B. DISCHARGE AIR SENSORS: In all applications, care shall be taken to ensure that the sensors are securely mounted as not to allow any vibration and installed in such a manner as to indicate the truest possible temperature.
- C. FREEZE/LOW-LIMIT THERMOSTAT: It shall be installed serpentine across the air entering the coil. In some cases, it may require being installed after the coil. Each application should be closely evaluated before installation.
- D. OUTSIDE AIR UNIT: All Outside Air Units, Air handling Units etc. shall be provided with current sensors on each of the supply and exhaust fans to provide fan status for each air handler fan.
- E. SMOKE SHUTDOWN: Coordinate with the Fire Alarm Contractor to insure a complete, code compliant installation.

### 3.4 VALVES, DAMPERS AND ACTUATORS

- A. Actuators may be factory installed. If not, factory installed, they shall be installed as per instructions by the terminal equipment manufacturer.
- B. Locations mounted above ceiling shall be marked on ceiling grid.
- C. Install damper motors on the outside of the duct in warm areas where possible, not in air stream or locations exposed to outdoor conditions.

### 3.5 WIRE MANAGEMENT, ELECTRICAL POWER, ETC.

- A. All work shall comply with the 2017 SCO Electrical Guidelines & Policies Section 26 02 05 division of work between the Division 23 & Division 26 contractors.
- B. Refer to CABLING section of this specification for additional requirements.
- C. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.
- D. All wiring and cabling in mechanical and electrical rooms shall be in conduit. No wiring or conduit can be exposed to view in any other area. Wiring above concealed ceiling shall route in bridge rings. Route wiring directly to cable tray from control points above the ceiling. Rough-in for control devices shall be in compliance with the requirements of the ELECTRICAL SPECIFICATIONS.
- E. Prior to installation, insure through coordination with all trades, that appropriate clearances (36" minimum) as required by the N.E.C. are maintained at all control panels, including unitary controllers for VAV terminals, heat pumps, etc.
- F. The contractor shall perform all temperature control interlock wiring. This shall include control valves, dampers, thermostats, indoor/outdoor HVAC systems, etc. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid

and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.

- G. All wiring shall be continuous runs. Any junctions must be made in metal enclosure.
- H. Grounding terminals shall be color coded green and yellow and shall be compatible with the other specialty terminals specified above and shall mount on the same DIN rail system. Units shall be arranged so that the wiring connected to them is grounded to the enclosure via the mounting rail. These terminals shall be provided for grounding cable shields at the points where the cables enter a control panel and terminate on the control panel terminal strip. Terminals shall be Entrelec M 4/5.3A.PI or equivalent by Weidmuller, Phoenix, or Allen Bradley.
- I. Only an electrical contractor licensed by the State with a licensed Master Electrician and a licensed on-site electrician can install the electrical wiring.

### 3.6 CABLING

- A. Refer to WIRE MANAGEMENT section of this specification for additional requirements.
- B. ALL CONTROL WIRING SHALL BE INSTALLED IN A WIRE MANAGEMENT SYSTEM TO INCLUDE CABLE TRAYS OR BRIDLE RINGS. NO EXCEPTIONS! COORDINATE WITH ELECTRICAL CONTRACTOR TO INSURE A COMPLETE WIRE MANGEMENT SYSTEM.
- C. Acceptable cable manufacturers are Belden, West Penn or Alpha.
- D. Cabling shall be plenum rated and installed above ceiling and within walls not exposed to view.
- E. A complete cabling system shall be furnished and installed, which shall adhere to the highest workmanlike standard of quality and appearance. Cabling shall be installed square with building lines and contained within a wire management system.
- F. All sizing of cabling shall be according to manufacturer's recommendations, but shall be a minimum of 18 AWG.
- G. Furnish a floor plan of the building indicating communication cable labeling and routing as well as addresses and branch wiring from the unitary devices. All cabling shall be labeled on both ends. The type, size and label of all cabling shall be indicated on submittal floor plan drawings.
- H. Wall space temperature sensor cabling (from the sensor to the unitary controller) shall have a minimum of four (4) conductors.
- I. All cabling shall be stranded. "NO" solid conductors will be accepted. All cabling shall be 100% shielded with appropriate drain wire and insulation.
- J. All cable connections shall be continuous run (including shield). Any junctions must be made in a metal enclosure, connections must be soldered, taped and the metal enclosure must be mechanically attached to the nearest ground. No wire nuts or crimped connections will be accepted. Note location of junction boxes on the as built floor plans. All cabling networking unitary controllers, and other networked equipment, shall be in soldered.

- K. All shields must be terminated as per manufacturer's recommendation. Shield termination requirements by the manufacturer must be provided with submittals.
- L. Wireless controllers are not approved unless specifically mentioned in the sequence of operations or noted on plans.

3.7 COMMISSIONING & VERIFICATION, FUNCTION PERFORMANCE TESTING & CHECKLISTS:

- A. 100% compliance with the requirements of this section is a condition of the Owner's acceptance and start of the warranty period.
- B. The contractor shall be responsible for completion of (1) their hardware checkout sheets and test reports, (2) Point-by-point confirmations of ALL points – this includes visual inspection of installed components, and (3) sequence of operation confirmation.
- C. This documentation and process shall be complete, approved and accepted by Engineer and Owner prior to acceptance. This information shall be documented as completed. A copy shall be delivered to the Engineer and Owner and included in the O&M manuals. Each subcontractor shall be responsible for completion of their own System Verification Checklists/Manufacturer's Checklists. Sample checklists shall be submitted to the Engineer and Testing Agent for approval.
- D. Air and water balancing shall be completed (and discrepancies resolved) before the contractor's final system check and before the acceptance test to be conducted in the presence of the Engineer.
- E. This project will be commissioned and the contractor shall be responsible for completing the functional performance testing of the control system sequences and graphics with the Commissioning Agent.

3.8 WARRANTY

- A. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final acceptance and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.
- B. The contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours. The contractor shall respond to the Owner's request for Emergency service (defined as life-threatening or creating the potential to cause property damage) during the warranty period within 4 hours.
- C. The contractor shall provide technical phone support to the owner during the warranty period for warranty related issues and for two years after the warranty period. If the technical support location of the contractor is outside of the toll-free calling area for the customer, the contractor shall have a toll-free number or accept collect calls for the purpose of providing technical support.



- D. During the warranty period, standard parts for the DDC system shall arrive at the facility within 48 hours of placing an order. Non-standard parts (requiring re-manufacturing or ordering from another supplier) shall be shipped within 96 hours.

END OF SECTION 230900

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## SECTION 230910 - FACILITY MONITORING SYSTEM

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. METERS AND GAGES FOR HVAC PIPING
  - 3. INSTRUMENTATION AND CONTROL FOR HVAC
  - 4. VARIABLE FREQUENCY MOTOR CONTROL
  - 5. HYDRONIC PUMPS
  - 6. DEDICATED OUTDOOR-AIR UNITS
  - 7. WATER-SOURCE UNITARY HEAT PUMPS

#### 1.2 SCOPE OF WORK

- A. The controls system for this project shall be a web-based digital controls system. All controllers, control interface hardware, services, installation, warranty, training, etc., shall be included as hereinafter specified. The system shall utilize a network controller and unitary" type controllers. Including such minor details not specifically mentioned or shown, as may be necessary for the complete operation of the system.
- B. The Contractor shall furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls. All labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned shall be included for the complete, fully functional and commissioned temperature controls system.
- C. The temperature control contractor shall provide all items, articles, materials, devices, operations or methods listed, mentioned or scheduled on the drawings including all labor, materials, equipment and incidentals necessary and required for their completion to provide a complete and operating temperature control system. This will include connecting to any mechanical equipment furnished with a control interface device and contacting the equipment suppliers and/or manufacturers for information for the proper interface to the equipment being furnished.
- D. Control sequences on plans. Provide all control equipment required to perform sequences described. Coordinate all dampers with the sheet metal contractor and equipment provider. It is the responsibility of the control contractor to ensure all required dampers in the sequence of operations are provided.

- E. Include all power wiring and cabling for the operation of the controls system. Refer to Electrical Division Specifications for additional requirements.
- F. APPROVED MANUFACTURER'S: Distech.
- G. The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.
- H. Network level components of the system – workstations, servers, etc. shall communicate using the BACnet protocol, as defined by ASHRAE Standard 135-2004. No gateways shall be used for communication to controllers furnished under this section.
- I. All interlocking wiring, wiring and installation of control devices associated with the equipment including the diffuser thermostats, VRF systems and split systems shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS system supplier and representatives of the Owner will review and check out the system – see System Acceptance and Testing section of this document. At that time, the BAS system supplier shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.
- J. Provide services and manpower necessary for commissioning of the system in coordination with the Mechanical Contractor, Balancing Contractor and Owner's representative.
- K. All work performed under this section of the specifications will comply with all governing codes, laws and governing bodies. If the drawings and/or specifications are in conflict with governing codes, the Contractor, with guidance from the engineer, shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.
- L. ABBREVIATIONS:
  - 1. TCC – Temperature Control Contractor
  - 2. I/O: Input/output.
  - 3. MS/TP: Master slave/token passing.
  - 4. PC: Personal computer.
  - 5. PID: Proportional plus integral plus derivative.

## PART 2 - PRODUCTS

### 2.1 NETWORK CONTROLLER

- A. Install the Network Controller in a surface mounted panel, NEMA type 12 enclosures, with a removable hinged door. Provide a flush mounted key lock. All control panels must be painted the same color and identified. The boxes are to be made from 16-gauge material. Panels should not be provided with knockouts.
- B. The BACnet NSC shall be classified as a "native" BACnet device, supporting the BACnet Network Server Controller (B-BC) profile. Controllers that support a lesser profile such as B-SA are not

acceptable. NSCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Server Controllers (B-BC).

- C. The Network Server Controller shall provide the interface between the LAN or WAN and the field control devices and provide global supervisory control functions over the control devices connected to the NRS.
- D. Control panels shall be constructed by a UL approved panel manufacturer. The standard used shall be UL508A. All proper labels are to be attached, a parts list and laminated copy of as-built control drawing will be in a door pocket. Panel shall meet arc flash requirements.
- E. The Network Controller shall be web-based and communicate BACnet IP. It shall issue all time schedules, summer/winter commands, customized trending, holiday scheduling, alarm handling, clock or other shared commands to all unitary controllers within the building network. If for any reason communications between the unitary(s) and the Network Controller is lost, the unitary(s) shall operate in a stand-alone manner (in day operation) until communications is restored. It shall also operate in the "summer" or "winter" mode as last commanded.
- F. The Network Controller shall be integrated and interoperable with the facility infrastructure and include user access to all system data locally over the Local Area Network (LAN) / Wide Area Network (WAN) within the building and remotely by a standard Web Browser over the Internet. Any computer connected to the network, utilizing a web browser and having the proper password.
- G. The Network Controller shall be a fully user-programmable, supervisory controller. It shall monitor the network of distributed unitary controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Controllers.
- H. The Network Controller shall have battery back-up to allow a minimum of seven days of operation. The Network Controller shall be composed of one or more independent, stand-alone, microprocessor to manage the network strategies described in Application software section. The network controller shall have ample memory to support its operating system, database and programming requirements. The operating system of the Network Controller shall manage the input and output communications signals to allow distributed unitary controllers to share real and virtual point information and allow central monitoring and alarms. The database and custom programming routines of the Network Controller shall be editable from a single operator station.
- I. The Network Controller shall be remotely monitored via the internet. Additionally, it shall include automatic emailing and texting out alarms, gathering alarms, reports and logs, programming and downloading database.
- J. The Network Controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
  - 1. Assume a predetermined failure mode.
  - 2. Emit an alarm.
  - 3. Display card failure identification.
- K. Under no circumstance shall more than 75% of the total number of sensor and control points be connected through a single Network Controller. Each DDC system component shall provide for the future addition of at least 20% of each type of the number of sensor and control points connected to that component including a minimum of one universal input and one universal output.

- L. A sub-network of SDCUs using the BACnet IP, BACnet MS/TP and/or Modbus RTU protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.

## 2.2 UNITARY CONTROLLER- PANEL CONTROLLER

- A. Unless otherwise specified, each piece of equipment shall have its own Unitary Controller (i.e., heat pump, RTU, heat pump loop, terminal unit, etc.). The Unitary Controller for each piece of equipment shall be mounted on the side of the unit. The Unitary Controller for all other equipment shall be mounted in a panel and properly labeled.
- B. Unitary Controllers shall communicate via BACnet MSTP. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each Unitary Controller that will communicate on the BACnet MS/TP Bus.
- C. Unitary Controllers used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F. All Unitary Controllers shall have an RJ-11 or similar type connection for monitoring or programming access by room or local equipment level with access to any unitary within the network without modification.
- D. Control panels shall be constructed by a UL approved panel manufacturer. The standard used shall be UL508A. All proper labels are to be attached, a parts list and laminated copy of as-built control drawing will be in a door pocket. Panel shall meet arc flash requirements.
- E. Unitary Controllers utilized in the network shall have full stand-alone capability including time of day and holiday scheduling as well as all energy management functions such as optimal start/stop, duty cycling, etc. The terminal unit Unitary Controllers may be pre-programmed with the project specific sequence of operation as specified for the application. Any re-programming of the electronics shall be performed on location using a portable personal computer with appropriate software or through the Network Controller. The entire unitary data base shall have the capability of being backed up and or downloaded locally.
- F. All points to have a unique digital input to the BAS system. The use of digital point count expanders is not an acceptable replacement to digital inputs to the unitary controller. The conversion of a single universal input channel to accept up to multiple voltage free contacts such as relay contacts, auxiliary starter contacts, differential pressure switches, etc. IS NOT ACCEPTABLE.
- G. All Unitary Controllers shall be fully application programmable. All control sequences within or programmed into the unitary controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery shall be retained.
- H. All unitary controllers shall be fully application programmable. Controllers require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the unitary controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- I. After a power failure, the Unitary Controller shall operate the control application using the current setpoints and configuration. Reverting to default or factory setpoints are not acceptable.

- J. Digital expanders, multiplexers or other devices which gang multiple signals into or out of a signal point are not allowed. Each input or output called for shall have its own discrete point on the controller. All points to have a unique digital input to the BAS system. The use of digital point count expanders is not an acceptable replacement to digital inputs to the unitary controller. The conversion of a single universal input channel to accept up to multiple voltage free contacts such as relay contacts, auxiliary starter contacts, differential pressure switches, etc. IS NOT ACCEPTABLE.
- K. Enclosures must be appropriately rated and properly installed and for their intended use. Enclosures installed in areas are subject to falling dirt and circulating dust, lint, fibers, and flyings as well as dripping or light splashing should be NEMA12. Mechanical rooms would typically fall under this category.
- L. Connect manual-reset limit controls independent of manual-control switch positions.

### PART 3 – EXECUTION:

- 3.1 A mandatory pre-installation meeting shall occur prior to the contractor beginning any work on site. This meeting shall be attended minimally the prime contractor, mechanical contractor superintendent, contractor superintendent, Engineer, Owner and Architect. The purpose of the meeting is to have the controls installer communicate their understanding of the system design and how the system is intended operate to the Engineer and get the Engineer's input and agreement. The agreement between the contractor and the mechanical engineer is to be thoroughly documented by the contractor for later reference.
- 3.2 The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.
- 3.3 The Ethernet LAN: This is a shared, routed system extended to each building by the Information Technologies. The new BAS/ATC will be connected to the LAN.
- 3.4 All labeling for this system shall utilize actual final room names and numbers. The room names and numbers on the Contract Documents may not be the Owner's exact requirements. Coordinate with the Owner to ensure compliance.
- 3.5 Include in the bid for the Controls Contractor to perform additional 40 on-site hours of on-site programming, adjustments, modifications, etc. as requested by the Engineer during the warranty period after the date of final acceptance for the project.
- 3.6 Minimum of 3' working clearance shall be provided in front of all enclosures and panels; clearances shall be ensured to permit the enclosure door to open at least 90 degrees from its closed position of all panels containing control components for servicing.
- 3.7 Wall mounted controllers shall be mounted at eye level for accessibility and service, and located within 50' of the system served, unless otherwise shown on plans.
- 3.8 Locations of terminal equipment controllers mounted above ceiling shall be marked on ceiling grid.

- 3.9 Unitary control panel power shall be on a dedicated circuit taken from nearest appropriate power electrical panel unless otherwise indicated.
- 3.10 Coordinate with equipment provided with factory controls field devices.
- 3.11 WIRE MANAGEMENT, ELECTRICAL POWER, ETC.
- A. Refer to SECTION 230500 Part 3.33 for Division of Work requirements between Divisions 23 and 26.
  - B. Refer to CABLING section of this specification for additional requirements
  - C. Refer to SECTION 260519, 260533, and 270528 for additional information.
  - D. System interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.
  - E. All wiring and cabling in mechanical and electrical rooms shall be in conduit. No wiring or conduit can be exposed to view in any other area. Conceal all wiring and cabling in conduit in wall from thermostats or other controls devices to above ceiling. Install conduit in wall from wall thermostats to above ceiling for cabling. Route wiring directly to cable tray from control points above the ceiling. Rough-in for control devices shall be in compliance with the requirements of the ELECTRICAL SPECIFICATIONS.
  - F. Any power for controls shall be fed from dedicated circuits in electrical panels, when provided for a project, and shall not be obtained from receptacles, lighting, or equipment circuits.
  - G. Prior to installation, insure through coordination with all trades, that appropriate clearances (36" minimum) as required by the N.E.C. are maintained at all control panels, including unitary controllers for heat pumps, etc.
  - H. The contractor shall provide all CAT6 cabling network cabling for a complete system. This shall include cabling to the Owner's data drop. The main system data drop will be provided by others.
  - I. All control circuits within the electrical panels shall be marked to indicate equipment served.
  - J. The contractor shall perform all temperature control interlock wiring. This shall include control valves, dampers, thermostats, indoor/outdoor HVAC systems, etc. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.
  - K. Provide one duplex outlet mounted inside the control panel and separately fused with a non-time delay fuse at 15 A at any panel location containing electronic control components. This receptacle may be served from the control panel 120 VAC power source.
  - L. All wiring shall be continuous runs. Any junctions must be made in metal enclosure.



- M. Grounding terminals shall be color coded green and yellow and shall be compatible with the other specialty terminals specified above and shall mount on the same DIN rail system. Units shall be arranged so that the wiring connected to them is grounded to the enclosure via the mounting rail. These terminals shall be provided for grounding cable shields at the points where the cables enter a control panel and terminate on the control panel terminal strip. Terminals shall be Entrelec M 4/5.3A.PI or equivalent by Weidmuller, Phoenix, or Allen Bradley.
- N. All new lighting control panels, new Building Automation Systems control panels, and new conventional HVAC control panels be certified as being constructed and wired in accordance with NFPA 70 110.3 (a) (1) and article 409.
- O. Contractor shall insure control panels have an identification label stating the "Certification Agency" such as UL, CSA, CE, etc. or a label of certification for each control panel by a qualified testing agency. Include with shop drawings.
- P. Only an electrical contractor licensed by the State of South Carolina with a licensed Master Electrician and a licensed on-site electrician can install the electrical wiring.

### 3.12 CABLING

- A. Refer to WIRE MANAGEMENT section of this specification for additional requirements.
- B. ALL CONTROL WIRING SHALL BE INSTALLED IN A WIRE MANAGEMENT SYSTEM TO INCLUDE CABLE TRAYS, BRIDLE RINGS, & CONDUITS. NO EXCEPTIONS! COORDINATE WITH ELECTRICAL CONTRACTOR TO INSURE A COMPLETE WIRE MANGEMENT SYSTEM.
- C. Acceptable cable manufacturers are Belden, West Penn or Alpha.
- D. A complete cabling system shall be furnished and installed, which shall adhere to the highest workmanlike standard of quality and appearance. Cabling shall be installed square with building lines and contained within a wire management system.
- E. All sizing of cabling shall be according to manufacturer's recommendations but shall be a minimum of 18 AWG.
- F. Furnish a floor plan of the building indicating communication cable labeling and routing as well as addresses and branch wiring from the unitary devices. All cabling shall be labeled on both ends. The type, size and label of all cabling shall be indicated on submittal floor plan drawings.
- G. Wall space temperature sensor cabling (from the sensor to the unitary controller) shall have a minimum of four (4) conductors.
- H. All cabling shall be stranded. "NO" solid conductors will be accepted. All cabling shall be 100% shielded with appropriate drain wire and insulation.
- I. All cable connections shall be continuous run (including shield). Any junctions must be made in a metal enclosure, connections must be soldered, taped and the metal enclosure must be mechanically attached to the nearest ground. No wire nuts or crimped connections will be accepted. Note location

of junction boxes on the as built floor plans. All cabling networking unitary controllers, and other networked equipment, shall be in soldered.

- J. All shields must be terminated as per manufacturer's recommendation. Shield termination requirements by the manufacturer must be provided with submittals.
- K. Wireless controllers are not approved unless specifically mentioned in the sequence of operations or noted on plans.

### 3.13 SYSTEM SOFTWARE

- A. System software will be the latest version available with upgrades provided for full warranty period and shall be fully licensed to the owner for all network controllers and servers. Refer to WARRANTY section of this specification for additional requirements.
- B. The BAS shall include trend logging screens accessible from tabs on the home page for building utilities usage.
- C. System software shall, at a minimum, provide:
  - 1. Monitor and supervise all control points.
  - 2. Add new points and edit system database.
  - 3. Change control setpoints, timing parameters and loop tuning of PID coefficients in all control loops in all control units.
  - 4. Enter programmed start/stop schedules.
  - 5. View alarm and messages.
  - 6. Modify existing control logic (or sequence of operation) in all control units.
  - 7. Upload/Download programs, databases, control parameters, etc.
  - 8. Modify graphic screens.
- D. Sequence of operation programming methodology - The application software shall be user programmable. Application programming shall be (1) Line type programming that uses text programming in a language similar to BASIC or FORTRAN, or (2) graphical block programming - The method of programming shall be by manipulation of graphic icon "blocks." Each block represents a subroutine containing the programming necessary to execute the function of the device that the block represents.
- E. Unitary Control Unit Database Archiving - The host software shall provide capability to upload sequence of operation, database, and other control parameters from each controller. Uploaded programs shall be retained on hard disk for system backup. Programs may be modified using Editor functions, and downloaded to individual controllers as desired. Downloading of databases shall not interrupt other multi-tasked functions that are ongoing.
- F. THIRD PARTY SOFTWARE PACKAGES: The host software shall provide the capacity to run third party software packages for word processing, spreadsheets, or database management programs. Use of third-party software shall not suspend operation of background tasks of multi-tasking operating system, such as alarm logging, and report generation.
- G. The Owner shall retain licenses to software for this project.
- H. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition off this contractor. Such license shall grant use of all programs and

application software to the Owner as defined by the manufacturer's license agreement but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.

### 3.14 GRAPHICS SCREENS AND TRENDS

- A. All graphics screens shall be submitted for review by Engineer. Provide the following animated, color graphics screens minimally:
- B. Entire floor plan home screen with OAT, Time and Date displays.
  - 1. Floor plan showing major zones,
  - 2. Click major zone displays enlarged floor plan of the zone showing individual heat pump zones & numbers. Include link to respective mechanical room.
  - 3. Click individual zone shows heat pump graphic. Display all data points from points list, occ/unocc schedule and setpoints, OAT, Time and Date.
- C. Color Graphic Screens shall be designed for all mechanical systems and shall include the following:
  - 1. A graphic shall be the starting page with the building graphically indicated. Break up the floor plan into zones to match Contract Documents. The building shall be the point of reference to enter into the respective building control system.
  - 2. All terminal equipment including but not limited to heat pumps, cabinet heaters, etc.
  - 3. All DOAS units.
  - 4. All floor plans indicating all actual room numbers, thermostats and mechanical equipment. Operator shall be capable of clicking on any equipment and pull up the respective graphic screen.
- D. Graphics to include floor plans with room numbers (as-built room numbers) and thermostat locations, links to flow diagrams for heat pumps, zone dampers, hydronic loop systems, outside air systems, domestic hot water and lighting controls.
- E. All new graphics shall match the existing system graphics, unless noted otherwise.
- F. The graphical programming software shall allow for interactive mouse-driven placement of block icons on the graphic screen and connection of block inputs to block outputs by means of drawing lines to form a graphic logic diagram. The user shall not have to manually input text to assign block input/output interconnections. Blocks shall allow entry of adjustable settings and parameters via pop-up windows.
- G. The clarity of sequence shall be such that the user has the ability to verify that the system programming meets the specs without having to learn or interpret a manufacturer's unique programming language. Provide a means for testing and/or debugging the control programs off-line (not communicating with control units) using operator entered values for physical inputs and time. Provide a means for testing and/or debugging the control programs on-line (communicating with control units), showing actual physical inputs and all block outputs in real time.
- H. Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time output values.
- I. All graphic software shall be in the html web browser format and support multiple simultaneous screens to be opened and resizable in a "Windows" type environment. All functions, except text

entry, shall be executable with a mouse. Graphic software shall provide for multitasking such that third party programs can be used while the Operator Workstation Software is on-line. Provide the ability to alarm graphically even when operator is in another software package. The software shall allow for Owner to create user defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics.

- J. The contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, coils, filters, dampers, etc.), mechanical system components (e.g., pumps, heat pumps, etc.), complete mechanical systems (e.g. VAV, etc.) and electrical symbols.
- K. The graphic development package shall use a mouse or similar pointing device to allow the user to perform the following:
  - 1. Define symbols
  - 2. Position items on graphic screens
  - 3. Attach physical or virtual points to a graphic
  - 4. Define background screens
  - 5. Define connecting lines and curves
  - 6. Locate, orient and size descriptive text
  - 7. Define and display colors for all elements
  - 8. Establish correlation between symbols or text and associated system points or other displays.
  - 9. Create hot spots or link triggers to other graphic displays or other functions in the software
- L. The Contractor shall include programming of 25-point trends as directed by the Engineer. These can be requested at any time during the project including the warranty period. Trend "change of state" for digital inputs. Trend analog points in 30-minute increments. Maintain trend history for 30 days. Include the following:
  - 1. Outside air temperature
  - 2. DOAS unit leaving air temperatures for each unit
  - 3. VFD speeds
  - 4. Critical room space temperatures
  - 5. Electrical power kW and kWh
  - 6. Others as directed in the field or specified on plans

### 3.10 TRAINING

- A. A formal on-site "Hands On" training session shall be conducted for the owner's maintenance personnel. This session shall be a minimum of three (3) (8) hour days to train the staff on setup, operation, and maintenance of all system(s) and/or devices. This will be at a time and location selected by the owner. One (1) additional eight (8) hour session shall be provided as "opposite season" training – generally 6 months into the warranty period. One (1) additional eight (8) hour session shall be provided at a later date. (This may be requested any time during the warranty period.) All training materials and books shall be provided. Both sessions shall be given by the manufacturer's "factory" technical representative. (This is defined as someone other than the installing contractor's representative.) All expenses are to be provided by the contractor. All training sessions shall be scheduled at owner's request.
- B. The contractor shall conduct training courses for designated personnel in operation and maintenance of system. Training shall be oriented to specific system being installed under his contract and shall be digitally recorded and submitted on flash drive by the contractor.

- C. Training shall be a mix of, test exercises, and actual keyboard entry and screen viewing at the operator's terminal. A curriculum shall be discussed and implemented based on the level of expertise of the employees. Hands-on experience and problem solving shall be emphasized.
- D. If during any training session, the trainer/owner finds more than three (3) items that need repair, the training session will be immediately terminated. The session will be rescheduled for another date. The re-scheduled training session will be carried out at no additional cost to the Owner.
- E. The training shall be oriented to making the owner self sufficient in the day-to-day use and operation of the DDC system.
- F. Additionally, the training shall include:
  - 1. System start-up, shutdowns, power outage and restart routines, alarms, security levels, changing setpoints, changing schedules and other parameters, overrides, freeze protection, manual operation, return to automatic operation, and resetting equipment.
  - 2. All screens shall be discussed, allowing time for questions.
  - 3. Information specifically focused on showing the owner methods of troubleshooting the mechanical systems using the DDC.
  - 4. Use of laptop and hand-held operator interface device, if applicable.
  - 5. Creating, modifying, viewing, downloading, and reloading, trend logs.
  - 6. Remote access to the system.
  - 7. The other training sessions shall be oriented toward answering specific questions from Owner's staff.
  - 8. The trainer must be well grounded in both DDC system operation and in mechanical systems service and shall be the programmer.
- G. This documentation and process shall be complete, approved and accepted by Engineer and Owner prior to acceptance. This information shall be documented as completed. A copy shall be delivered to the Engineer and Owner and included in the O&M manuals.

3.11 COMMISSIONING & VERIFICATION, FUNCTION PERFORMANCE TESTING & CHECKLISTS:

- A. 100% compliance with the requirements of this section is a condition of the Owner's acceptance and start of the warranty period.
- B. The contractor shall be responsible for completion of (1) their hardware checkout sheets and test reports, (2) Point-by-point confirmations of ALL points – this includes visual inspection of installed components, and (3) sequence of operation confirmation.
- C. This documentation and process shall be complete, approved and accepted by Engineer and Owner prior to acceptance. This information shall be documented as completed. A copy shall be delivered to the Engineer and Owner and included in the O&M manuals. Each subcontractor shall be responsible for completion of their own System Verification Checklists/Manufacturer's Checklists. Sample checklists shall be submitted to the Engineer and Testing Agent for approval.
- D. Air and water balancing shall be completed (and discrepancies resolved) before the contractor's final system check and before the acceptance test to be conducted in the presence of the Engineer.

- E. This project will be commissioned, and the contractor shall be responsible for completing the functional performance testing of the control system sequences and graphics with the Commissioning Agent.

### 3.12 WARRANTY & SOFTWARE LICENSES

- A. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.
- B. The contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours. The contractor shall respond to the Owner's request for Emergency service (defined as life-threatening or creating the potential to cause property damage) during the warranty period within 4 hours.
- C. The contractor shall provide technical phone support to the owner during the warranty period for warranty related issues and for two years after the warranty period. If the technical support location of the contractor is outside of the toll-free calling area for the customer, the contractor shall have a toll-free number or accept collect calls for the purpose of providing technical support.
- D. During the warranty period, standard parts for the DDC system shall arrive at the facility within 48 hours of placing an order. Non-standard parts (requiring re-manufacturing or ordering from another supplier) shall be shipped within 96 hours.
- E. Operator workstation software, project-specific software, graphic software, database software, and firmware updates which resolve known software deficiencies as identified by the contractor shall be provided and correctly installed at no charge during the warranty period.
- F. Provide licensed electronic copies of all software for each workstation, laptop, server. This includes, but is not limited to: project graphic images (editing/modifying/creating), project database, troubleshooting and debugging programs, project-specific programming code and all other software required to operate and modify the programming code (including software at system level, primary control units, secondary control units, and all communication software). Any hardware devices (cables, protection devices) required to operate the software/hardware shall also be provided.
- G. All additional licensing needed for this project shall be supplied by contractor. Software license shall not expire or utilize any sort of protection hardware device for its use. In any case owner shall be free to direct the modification of any software license, regardless of supplier to allow open access to all controllers. Owner shall hold the software and firmware licensing. Software license shall not expire or utilize any sort of protection hardware device for its use.
- H. System software shall be the latest version available with upgrades provided at the end of the warranty period and shall be fully licensed to the Owner for the entire system. Supply all software necessary for configuration of, modification, editing or communicating to any of the unitary devices. Software shall be capable of uploading and down-loading the entire unitary data base or any part of the automated system for backup or archiving. Software shall be "IBM compatible".

END OF SECTION 230910

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## SECTION 230920 - VARIABLE FREQUENCY MOTOR CONTROL

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. INSTRUMENTATION AND CONTROL FOR HVAC
  - 3. FACILITY MONITORING SYSTEM
  - 4. HYDRONIC PUMPS
  - 5. DEDICATED OUTDOOR-AIR UNITS

#### 1.2 SCOPE OF WORK

- A. All VFD shall adhere to the latest manufacturers recommended installation, wiring and networking practices.
- B. Include all power wiring and cabling for the operation of the VFD. Refer to Electrical Division Specifications for additional requirements.
- C. The distributor shall have an established working relationship with the manufacturer of not less than five years and shall have prior approval from the Owner and Engineer and are the only allowed suppliers and/or installing contractors. The distributor shall have a local office within 100 miles of the project site and provide service and/or replacement parts within a 24-hour notification of a control failure.

### PART 2 – PRODUCTS:

#### 2.1 VARIABLE FREQUENCY DRIVES (VFDs):

- A. VFDs shall be as manufactured by ABB, Danfoss, or Yaskawa. These are the only acceptable manufacturers. All VFDs for the project shall be by the same manufacturer (no exceptions).
- B. VFDs shall consist of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor.
- C. The VFD shall be capable of operation from AC voltage in two ranges 208–240 VAC  $\pm$  10%, or 380–480 VAC  $\pm$  10%. 50/60 HZ operation,  $\pm$  2 hertz.
- D. The VFD enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated, suitable operating conditions: 0 – 400 C continuous. Drives that have thermal cut out circuits, or that cannot operate continuously at 400 C shall not be acceptable. Altitude 0 to 3300 feet above sea level, up to 95% humidity, non-condensing.

- E. The VFD shall produce an adjustable AC voltage/frequency output for step less motor speed control utilizing sine wave coded Pulse Width Modulation (PWM) The Drive shall provide automatic power factor correction and a .98 displacement power factor by incorporating a full wave diode bridge rectifier. The VFD shall have an overload rating of 110% of nominal rated current for 1 minute out of every 10 minutes of operation, which is an acceptable overload for centrifugal loads.
- F. The VFD shall include a built-in first environment RFI/EMI filter and be CE and UL labeled. It shall also meet the CE requirement of EN61800-3 which provides an actual test procedure that shows that the VFD is immune from RFI/EMI interference and at the same time does not emit RFI/EMI noise that would interfere with other sensitive equipment near the VFD.
- G. The VFD shall include as a minimum a 5% dual DC link and AC line reactor for a clean harmonic signature, which aides in complying with IEEE-519-1992 recommended levels. The VFD manufacturer and representative shall assist in ensuring that the VFD's applied meet IEEE-519-1992 by completing a computer aided Harmonic Analysis of the complete system. Refer to electrical drawings and coordinate with electrical contractor for all required information to complete analysis.
- H. The VFD shall include as a standard a built-in digital keypad/display panel. This panel shall provide "Hand" off "Auto" selection, and a manual speed adjustment via up and down arrows. All faults and warnings shall be provided in "Plain English" for operation without a manual. The drive shall have a complete manual stored in memory that can be accessed with a single keystroke. This display shall be password protected and allow all setup parameters to be adjusted only by authorized personnel.
- I. The VFD shall include built in Startup, Diagnostic, and Maintenance assistants, which allow for step-by-step startup procedures, troubleshooting, and the ability to indicate when the VFD and the system it is applied to needs preventive maintenance performed.
- J. The VFD shall include a real time clock with a day/date stamp for troubleshooting purposes. In addition, with the use of this clock the drive shall be capable of stand-alone operation and act as a unitary controller.
- K. The VFD shall include (2) Analog inputs either 4–20 mdc or 0-10 vdc, (6) programmable Digital Inputs, (2) Programmable analog Outputs, (3) Form C Relay output rated 2 amps continuous minimum, and (2) PID Process controllers.
- L. The VFD keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (LED and alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words.
- M. BYPASS: All VFD's shall be provided with an integral Bypass circuit which includes a pair of 115V electrically interlocked contactors for drive and bypass operation. The drive shall include a main input circuit breaker, drive input service/isolation switch, and motor overload protection adjustable for either Class 10, 20 or 30 operation. The bypass shall include a built in status display which shows via colored LED's the system operational status including safeties and run permissive for ease of operation. The Bypass shall have its own interactive, programmable keypad. The Bypass shall provide single-phase protection for the motor while operating in



bypass. Bypass that does not protect the motor from single-phase operation shall not be acceptable.

- N. The drive and bypass system shall have embedded serial communication capabilities that allow direct connection to Siemens and BACnet automation systems as part of the drives software suite without the need for extra hardware cards or gateways. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC).

#### PART 3 – EXECUTION:

- 3.1 The work includes all labor, materials, and related items to completely furnish and install, start up and test, and place into service the Variable Frequency Drives (VFDs) indicated and scheduled on the Drawings and described in the Specifications.
- 3.2 All VFDs shall be provided and installed in strict accordance with the manufacturer's recommendations.
- 3.3 Factory-authorized startup for each drive is mandatory. Provide a written record of the startup of each unit. Start up and programming by a factory-authorized technician. At startup, lockout any speed with the VFD that does not meet the vibration allowanced of the equipment manufacturers.
- 3.4 A parts and labor warranty of 3 years from startup and 2 years from the date of final acceptance shall be included. Warranty shall include travel time and expenses.

END OF SECTION 230920

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## SECTION 232100 - EXCAVATION, TRENCHING, BACKFILLING AND GRADING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall include all excavating, filling, grading, and related items required to complete their work as shown on the drawings and specified herein or as required to complete, connect and place all mechanical systems in satisfactory operation.
- 1.3 Unless otherwise shown or required, provide separate trenches for sewers, water lines and other underground raceways, with a minimum of 10 feet measured from outside diameter between pipes. In locations, such as close to buildings where separate trenches for sewers and water lines are impractical, lay the water pipe on a solid shelf at least 2'-0" above the top of the sewer and 2'-0" to the side.
- 1.4 Water lines crossing under sewer lines, or crossing less than 2 feet above sewer lines, must be concrete encased for a distance not less than 5 feet on either side of the point of crossover.

### PART 2 – EARTHWORK CLASSIFICATION:

- 2.1 Without regard to the materials encountered, all excavation and materials excavated shall be unclassified. Materials to be excavated shall be unclassified, and shall include earth, rock, concrete or any other obstructions encountered in excavation and/or trenching to install underground utility pipes or other equipment.
- 2.2 Include all costs for rock removal, including mass rock and trench rock in the bids. No adjustment in the contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in the excavating. The Contractor shall be responsible for the removal of all materials encountered as required for the installation of the work.
- 2.3 It shall be distinctly understood that references to rock, earth, topsoil or any other excavated or non-excavated material or other material on the construction plans, cross section, contract documents, technical specification or provisions, whether in numbers, words, letters, lines or graphically shown, is solely for information for the Engineer and Owner. This information shall not be taken as an indication of the classification of the material to be excavated, bored or removed by any method, including drilling and blasting, or materials not removed. This information shall not be taken as to the quantity of either rock, earth, topsoil, or any other material involved, or the quality of the material such as hardness, wetness, workability or suitability of the material either during excavation and construction or as a material to be reused during construction.
- 2.4 The Contractor shall draw their own conclusions as to the surface and sub-surface conditions to be encountered during construction of this project. The Engineer and Owner does not give any guarantee or warranty as to the accuracy of the data shown and no claim will be considered for

additional compensation when the materials encountered are not in accord with the information shown.

- 2.5 Refer to Specification Division EARTHWORK located in the Site Work portions of the Specifications and Civil Drawings for additional information. Also refer to the GEOTECHNICAL report included in the Front End of the Specifications.

### PART 3 – BENCH MARKS AND MONUMENTS:

- 3.1 Maintain carefully all bench marks, monuments and other reference points. If disturbed or destroyed, replace as directed.

### PART 4 – EXCAVATION:

- 4.1 Excavate trenches of sufficient width for proper installation of the work. Excavate to 6" below the bottom of new pipes for installation of compacted grillage.
- 4.2 Sheet and brace trenches as necessary to protect workers and adjacent structures. Comply with local regulations or, in the absence thereof, with the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc., and current OSHA Standards. Do not remove sheeting until trench is backfilled sufficiently to protect pipe and prevent injurious caving. Where removal of sheeting and/or bracing is hazardous, leave in place. Cut off such sheeting not to be removed at least 3 feet below finished grade.
- 4.3 Rules and regulations governing the respective utilities shall be observed in executing all work under this Division. Active utilities discovered in the course of excavation shall be protected or relocated in accordance with written instructions from the Engineer. Inactive and abandoned utilities encountered in trenching operations shall be removed and abandoned with ends plugged or capped in accord with current codes and safe practice. If in doubt, contact Engineer.
- 4.4 Machine excavation shall not be allowed within ten (10) feet of existing electric lines, natural gas lines or other lines carrying combustible materials. Use only hand tools.
- 4.5 The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted unless authorized in writing by the Engineer. Any damage to existing structures, exterior services, or rock intended for bearing, shall be corrected at the responsible Contractor's expense.
- 4.6 Perform final grading of trench bottoms by hand tools; carry machine excavation only to such depth that soil bearing for pipes and raceways will not be disturbed. Grade the bottom of trenches evenly to insure uniform bearing for all piping and raceways. Cut bell holes as necessary for joints and jointmaking. Except as hereinafter specified, bottom of trenches for bell and spigot pipe, flanged pipe, etc. shall be shaped to the lower quadrant of pipe with additional excavation for bell or flange. Piping installed where it rests on bell or flange and/or is supported with blocks or wedges will not be accepted.
- 4.7 Keep trenches free from water while construction therein is in progress. Under no circumstances lay pipe or appurtenances in water. Pump or bail water from bell holes to permit proper joining

- of pipe. Any dewatering from this Contractor's trenches which is required during construction, shall be included in this Contract.
- 4.8 In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, utility lines, large trees to remain, etc. The Contractors shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage or any other damage incurred in the course of excavation shall be at the responsible Contractor's expense.
- 4.9 Use surveyor's level to establish elevations and grades.
- 4.10 Machine excavation shall be held a sufficient distance from foundations and footings to insure no damage to same. Contractors shall accept full responsibility and pay for repairs and/or replacement of structural members, footings, etc.
- 4.11 The Contractor shall accept the site as it is and remove all trash, rubbish and material from the site prior to starting excavation work.
- 4.12 The Contractor shall provide and maintain barricades and temporary bridges around excavations as required for safety. Temporary bridges shall be provided where excavations cross paved areas and walks. The Contractor shall maintain these bridges in a safe and passable condition for all traffic until removal. Refer to OSHA Standards for such installations and comply with same in all details.
- 4.13 Pay particular attention to existing utilities and lines to avoid damage. The locations of existing lines which are indicated on the plans were taken unconfirmed from drawings prepared for previous construction and locations are approximate only. Also, certain water, gas, electric, storm and sanitary sewer lines and other underground appurtenances, active or abandoned, may not appear on the drawings. It shall be each Contractor's responsibility to ascertain the location of all lines and excavate with caution in their area.
- 4.14 Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor's expense.

#### PART 5 – BACKFILL, COMPACTION AND SURFACE REPAIR:

- 5.1 Backfilling for Mechanical Work shall include all trenches, manhole pits, storage tank pits, and/or any other earth and/or rock openings which are excavated under this Contract. Backfilling shall be carefully performed and the surface restored to its original level to receive new finish. Wherever trenches and earth openings have not been properly filled and/or settlement occurs, they shall be re-excavated, re-filled and properly compacted, smoothed off and finally made to conform to the level of the original ground surface.
- 5.2 All trenches shall be backfilled with 6" of manufactured sand or #8 crushed stone after finished excavation. Install the new pipe on the compacted fill material. Install tracer wire on pipe. Apply any special coatings to the pipe. Also perform all required pressure tests and check the grade of the pipe to ensure that it is correct and free of swags, bows or bends. Once coatings and testing are complete, backfill the pipe bed to 12" above the top of the pipe with specified compacted fill material. Backfill the remainder of the trench with earth (rock and debris free)

- tamped at 6" intervals. Water settling of backfill is permitted only as an aid to mechanical compacting.
- 5.3 Backfill and compact beneath areas to be seeded or sodded within six (6) inches of finished grade. The remaining six (6) inches shall be backfilled with clean top soil.
- 5.4 Backfill and compact beneath paved areas, walks, etc. shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill or unstable soil.
- 5.5 Wherever, in the opinion of the Engineer, the soil at or below the requisite pipe grade is unsuitable for supporting piping, special support shall be provided as directed by the Engineer.
- 5.6 Unsuitable material and surplus excavated material not required for backfill shall be removed from the site. The location of dump and length of haul shall be the affected Contractor's responsibility.
- 5.7 Provide and place any additional fill material from off the site as may be required for backfill. Fill obtained from off site shall be of kind and quality as specified for backfill and the source approved by the Engineer and shall be brought to the site by the Contractor requiring the fill.
- 5.8 If not specified or indicated elsewhere in the Contract Documents to be performed by Others, the Contractor shall lay new sod over their excavation work for existing disturbed grassy areas. Level, with adjacent surface, compact and water in accord with sound sodding practice.
- 5.9 Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated as follows.
- 5.10 At a minimum, fill in grass areas shall be compacted to 90% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.
- 5.11 At a minimum, fill in concrete or asphalt area shall be compacted to 98% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.
- 5.12 Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.
- 5.13 Grading Outside Building Lines:
- 5.13.1 All materials used for backfill around structures shall be of a quality acceptable to the Engineer and shall be free from large or frozen lumps, large rocks, wood, and other extraneous material. All spaces excavated and not occupied by footings, foundations, walls or other permanent work shall be refilled with earth up to the surface of the surrounding ground, unless otherwise specified, with sufficient allowance for settlement.

- 5.13.2 In making the fills and terraces around the structures, the fill shall be placed in layers not exceeding 8 inches in depth and shall be kept smooth as the work progresses. Each layer of the fill shall be compacted. Sections of the fill immediately adjacent to buildings or structures shall be thoroughly compacted by means of mechanical tamping or hand tamping as may be required by the conditions encountered. All fills shall be placed so as to load structure symmetrically.
- 5.13.3 As set out hereinbefore, rough grading shall be held below finished grade and then the topsoil which has been stockpiled shall be evenly spread over the surface. The grading shall be brought to the levels as specified. Final dressing shall be accomplished by hand work or machine work, or a combination of these methods as may be necessary to produce a uniform and smooth finish to all parts of the regrade. The surface shall be free from clods greater than one inch in diameter. Excavated rock (1" and smaller) may be placed in the fills, but is shall be thoroughly covered. Rock placed in fills shall not be closer than 24 inches from finished grade. Refer to Specification Division EARTHWORK.
- 5.14 Maintenance Settling: Where settling is measurable or observable at excavated areas during Project Warranty Period, remove surface (pavement, concrete or any other surface or finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration.
- 5.15 Disposal of Excess Non-organic Soil and Rock: Any excess excavated waste material shall become the property of the Contractor and shall be disposed of by the Contractor off site at no additional cost to the Owner.
- 5.16 Unless otherwise directed by the Owner during construction, excess topsoil and subsoil suitable for fill shall be disposed of by the Contractor off site at no additional cost to the Owner.

#### PART 6 – MINIMUM DEPTHS OF BURY TO TOP OF PIPE:

- 6.1 In the absence of other indication, the following shall be the minimum depth of bury to top of pipe of exterior utility lines. Check drawings for variations.
- |       |                            |                              |
|-------|----------------------------|------------------------------|
| 6.1.1 | Geothermal Lines           | 30 inches below final grade. |
| 6.1.2 | All Other Lines Not Listed | 36 inches below final grade. |
- 6.2 All exterior lines shall have a minimum earth cover of thirty (30) inches to top of pipe, unless otherwise indicated.

END OF SECTION 232100

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## SECTION 232113 – HYDRONIC PIPING

### PART 1 – GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. Each Contractor's attention is also directed to Specification Section HANGERS, CLAMPS, ATTACHMENTS, ETC.
- C. The Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR HVAC.
- D. The Contractor's attention is directed to Specification Section INSULATION - MECHANICAL.
- E. The Contractor's attention is directed to Specification Section PIPE FILLING, CLEANING, FLUSHING, PURGING AND CHEMICAL TREATMENT.

#### 1.2 SCOPE

- A. Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified. Materials shall comply with the "Buy American Act".
- B. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.
- C. The piping indicated shall be installed complete and shall be of the size indicated. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineer. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.
- D. Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.
- E. Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.
- F. Dielectric couplings or through ways shall be provided at all connections of dissimilar materials.
- G. Nipples shall be of the same material, composition and weight classification as pipe with which installed.
- H. Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief or exhaust plenums.

- I. Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineer.
- J. When connecting to an existing hydronic water system (chilled, hot, etc.), the Contractor shall include cost to drain the existing piping system and refill with water/closed loop chemicals to match existing fluid. If the building is occupied, and the drain down will affect services to these occupied areas, then the systems shall be drained and refilled over a weekend at a time acceptable to the Owner. Refer to Specification.

## PART 2 – PRODUCTS

### 2.1 UNIONS, FLANGES AND WELDED TEES

- A. Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.
- B. Dielectric insulating couplings or other ways shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.
- C. Tee connections for welded pipe shall be assembled with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is 2/3 the run size or smaller. Weld-o-let and thread-o-let branch connections are acceptable.

### 2.2 STANDARDS

- A. All piping and material shall be new, comply with the “Buy American Act” and shall conform to the following minimum applicable standards:
  - Steel pipe; Schedule 40; ASTM A-53.
  - Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.
  - Cast iron soil pipe; ASA A-40.1 and CS 188-59.
  - Cast iron drainage fittings; ASA B16.12.
  - Cast iron screwed fittings; ASA B16.4.
  - Welding fittings; ASA B16.9.
  - Cast brass and wrought copper fittings; ASA B16.18.
  - Cast brass drainage fittings; ASA B16.23.
  - PVC pipe; Schedule 40; ASTM D-1785.
  - PVC pipe; Schedule 40; ASTM D2665 and D1784. Piping must be installed in compliance to the manufacturer’s recommendations which shall be made available to the plumbing inspector.

## 2.3 HVAC PIPING APPLICATIONS

### A. HVAC Hydronic Piping

1. System Types:
  - a) Dual Temperature (2-pipe)
2. 2" and Smaller: Schedule 40 black steel pipe with screwed fittings or Type "L" hard copper tubing with wrought copper fittings and 95/5 solder.
3. 2" and Smaller: Installation-Ready™ fittings for schedule 40 plain end carbon sizes ½" through 2". Fittings shall consist of a ductile iron housing, complete with pre-lubricated EPDM gasket, and designed for direct stab installation. System rated for a working pressure of 300 psi. QVSD P07, P10, P89.
4. Schedule 40 Victaulic 107/W07 or approved mechanical grooved pipe couplings and fittings with a minimum 125# rating. Install gaskets as recommended by the manufacturer. Piping system shall be rated for minimum of 250 degrees F water temperature. Mechanical grooved piping may not be used if system water temperature exceeds 250°F. All grooved components must be of one manufacturer.

### B. Geothermal/Heat Pump Loop Piping

1. Mains and branches – Piping shall be virgin polyethylene with a PE 3408 piping formulation and 345464C or greater cell classification. Pipe shall be SDR 15.5, minimum pressure rating of 110 psi at 73.4°F.
2. Individual Heat Pump Runouts - Type "L" hard copper tubing with wrought copper fittings and 95/5 solder.
3. Special Note: Takeoffs and branch piping to individual coils or heat pumps shall not be connected to the top of hydronic mains. Connection to mains shall be at the side of the main. Also refer to details on the drawings.
4. Transitions from HDPE to Copper – Factory Manufactured Transition required with brass or stainless steel threads. No metal threads shall be inserted into polyethylene piping, and no polyethylene threads shall be inserted into metal piping.
5. The only acceptable method for joining pipe is by a heat fusion process. Pipe shall be butt or socket fused in accordance with pipe manufacturer's procedures. All piping work shall be performed in accordance with Specification Section – GEOTHERMAL LOOP SYSTEM. Victaulic style 905/908 couplings may be utilized on above ground HDPE applications.

### C. Exterior Geothermal Piping: Refer to Specification Section – GEOTHERMAL LOOP SYSTEM.

### D. Air Vent Discharge Lines: Type "L" soft copper; wrought copper fittings, 95/5 solder. Pipe to a suitable drainage location.

### E. Condensate Drain Lines Type "M" copper tubing with sweat fittings and 95/5 solder.

## PART 3 – EXECUTION

- 3.1 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

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- 3.2 All piping shall be installed straight and true, parallel or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers and other building openings.
- 3.3 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants.
- 3.4 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.
- 3.5 Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation.
- 3.6 In metal buildings or buildings with light gauge trusses, support piping with standard pipe hangers with C-clamp connection to main structural members (not perlins), use angle steel cross pieces between main structural members where required to provide rigid support.
- 3.7 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.
- 3.8 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.
- 3.9 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to insure that no foreign matter is lodged therein.
- 3.10 All hot and cold water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.
- 3.11 Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing. If in doubt, consult Engineer.

- 3.12 Apply approved pipe dope for service intended to all male threaded joints. The dope shall be listed for intended use.
- 3.13 Eccentric reducers shall be used where required to permit proper drainage and venting of pipe lines; bushings shall not be permitted.
- 3.14 High points of closed loop chilled water, hot water and geothermal systems shall have manual air vents as required unless automatic air vents are specifically indicated. Pipe to suitable drainage point.
- 3.15 Installation of pipe shall be in such a manner as to provide complete drainage of the system, whether detailed or not on plans. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be ½" size ball valves with ¾" hose thread end and vacuum breaker. Label each drain valve.
- 3.16 Where plastic piping penetrates a fire rated assembly, it shall be replaced with a threaded metal adapter and metal pipe or whatever means necessary to maintain the separation rating in accordance with local plumbing and fire codes.
- 3.17 When running any type of pipe below a footing, perpendicular to the footing, the area underneath the footing and in the zone of influence shall be backfilled with concrete. The zone of influence is the area within a 45 degree angle projecting down from the top edge of footing on all sides of the footing.
- 3.18 When running any type of pipe below a footing, parallel to the footing, the area underneath the zone of influence shall be backfilled with 4" of crushed stone or sand bedding under the pipe. Each pipe section shall be anchored into unexcavated earth on both ends with deadman anchor system. The remainder of the trench in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45 degree angle projecting down from the top edge of the footing on all sides of the footing.
- 3.19 PIPE TESTING:
  - A. Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.
  - B. Dual temperature water piping systems shall be subjected to a hydrostatic test of 250#. The system shall be proven tight after a twenty-four (24) hour test.
  - C. Geothermal water piping systems shall be subjected to a hydrostatic test of 150 psi. The system shall be proven tight after a twenty-four (24) hour test.
  - D. The Contractor shall perform all additional tests that may be required by all governing agencies.
  - E. Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

### 3.20 PITCH OF PIPING

- A. All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:
- B. CONDENSATE DRAIN LINES FROM COOLING EQUIPMENT: Not less than  $\frac{1}{4}$ " per foot in direction of flow.
- C. ALL OTHER LINES: Provide ample pitch to a low point to allow 100 percent drainage of the system.

END OF SECTION 232113.

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## SECTION 23 2113.33 – GROUND-LOOP HEAT-PUMP PIPING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

### PART 2 – CONTRACTOR QUALIFICATIONS:

- 2.1 The loop installer/contractor shall have a current International Ground Source Heat Pump Association (IGSHPA) certification, having completed an IGSHPA training course in the fundamentals of design, installation, and operation of ground source systems, and having passed the IGSHPA certification examination.
- 2.2 Ground heat exchanger fabricators shall have completed a heat fusion school in which each participant has performed a heat fusion procedure under direct supervision of a IGSHPA Certified Heat Fusion Technician. The Fusion Technician shall be thoroughly familiar with heat fusion procedures and have had formal training at a heat fusion school under direct supervision of an IGSHPA certified instructor.
- 2.3 Local and state laws, ordinances, and regulations as they pertain to buried pipe systems shall be strictly followed.
- 2.4 All Geothermal Contractors and any subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.
- 2.5 All geothermal subcontractors bidding the geothermal work must have completed one project of 100% this subcontract cost size and two projects of 70% this subcontract cost size in the Virginia region and is familiar with the drilling conditions, including the possibility of the Karst conditions.

### PART 3 – SUBMITTALS:

- 3.1 Reference Specification Section SHOP DRAWINGS, MAINTENANCE MANUALS, AND PARTS LIST for additional requirements.
- 3.2 Submit the following items before construction activities:
- Manufacturer's specification sheets and installation instruction for each component of the system, showing manufacturer, pipe or tube weight, pressure rating, fitting type and joint type for each piping system.
  - Manufacturer's data for geothermal headers, piping, valves, fittings, and components.
  - Manufacturer's data for the grout mixture. Submit details on grouting procedures, methods and equipment.
  - Written flushing, purging, pressure and flow testing plan. Include purge cart cut sheets.

3.3 Submit the following items after construction activities:

- Geothermal loop fluid test results.
- Grout testing results for 10% of vertical bores.
- Written results of flushing, purging, pressure and flow testing.
- Schedule dates for warranty period flushing, purging, etc.
- Survey/Record Drawings with dimensions from fixed benchmarks, depths and sizes.
- Written tracer wire test results.
- Submission of the completed items above is a condition of acceptance and closeout for the Project.

PART 4 – WARRANTY:

- 4.1 The entire ground loop system and backfill from a point 5'-0" inside the building shall be warranted for five years from date of substantial completion against any leakage or failure.

PART 5 – PIPING MATERIALS:

- 5.1 Acceptable pipe materials for the underground buried portion of the ground heat exchanger are polyethylene as specified in this Section. Piping shall be listed for closed-loop ground source geothermal application. The pipe and fitting of the buried system shall be warranted by the manufacturer for ground source heat pump service.
- 5.2 ACCEPTABLE MANUFACTURERS: Driscoplex 5300 Climate Guard, Centennial Plastics, Charter Plastics, Flying W Plastics, Lamson Vylon Pipe, PolyPipe, Inc.
- 5.3 Manufacturer shall supply a written warranty of 25 years or greater, specifying material replacement and labor allowance.
- 5.4 All pipe and heat fused materials shall be manufactured from a virgin polyethylene extrusion compound material in accordance with ASTM D-2513, Sections 4.1 and 4.2. Pipe shall be manufactured to outside diameters, wall thickness, and respective tolerances as specified in ASTM D-3035 and ASTM F-714 (3" and larger). Fittings shall be manufactured to diameters, wall thicknesses, and respective tolerances as specified in ASTM D-2683 for socket fittings and ASTM F-1055 for electrofusion fittings.
- 5.5 The pipe material shall maintain a 1600 psi hydrostatic design basis at 73.4 degrees F per ASTM D-2837, and shall be listed in PPI TR4 as a PE4710 piping formulation. The material shall be high density, polyethylene extrusion compound having a cell classification of PE445574 as specified in ASTM D-3350 except this material shall exhibit zero failures (F0) when tested for 192 or more hours under ASTM D-1693, condition C, as required in ASTM D-3350.
- 5.6 Pipe shall be manufactured in accordance with ASTM D-3035 and sized as follows:
- Pipe sizes 1¼" or less: DR 9 AND rated @ 250 psi.
  - Pipe sizes 1½" – 2": DR 15.5
  - Pipe sizes 3" and larger; DR 17
- 5.7 Sufficient information shall be permanently marked on the length of the pipe as defined by the appropriate ASTM pipe standard. Piping shall also have permanent factory length markings.



PART 6 – PIPE JOINING METHODS:

- 6.1 The only acceptable method for joining buried pipe systems is by a heat fusion process.
- 6.2 Polyethylene pipe shall be butt or socket fused in accordance with pipe manufacturer's procedures.
- 6.3 "U" bends fittings shall be used at bottom of the vertical bores. "U" bend fitting shall be manufactured by manufacturer of piping materials.

PART 7 – FLUSHING, PURGING, PRESSURE AND FLOW TESTING:

- 7.1 Refer to Specification Section HVAC WATER TREATMENT, CLEANING FILLING, AND PURGING FOR HVAC for additional information and coordination requirements.
- 7.2 Refer to Specification Section TESTING, ADJUSTING AND BALANCING FOR HVAC for additional information and coordination requirements.
- 7.3 Include in the bid an additional, complete, piping network purge at substantial completion and at 3, 6, 9 and 12 months from substantial completion.
- 7.4 Successful flushing and purging is critical and shall be accomplished and documented. Notify Engineer prior to flushing and purging. Submit flushing and purging plan to engineer two (2) months prior to commencing this work.
- 7.5 Vertical loops shall be pressure tested before installation, and all horizontal components of the ground heat exchanger will be flushed, pressure and flow tested prior to backfilling. All fusion joints and loop lengths shall be checked to verify that no leaks have occurred due to fusion joining or shipping damage. Heat exchangers shall be tested hydrostatically at 150% of the pipe design rating or 300% of the system operating pressure (whichever is greater). No leaks shall occur within a 120 minute period.
- 7.6 The type of purging cart/equipment is critical to successful flushing and purging. The purge cart shall include a pump that minimally develops 500 gpm of flow at 130 feet of head pressure developed. It shall include a large purge return tank, interconnection piping, inlet/outlet pressure gauges, water flow readout display reversing valve and 4" flexible hose connection. Coordinate so that the header purge ports match purge cart couplings. The first circuit purged after hose connection shall be purged minimally one hour to remove extra air introduced from the hoses. Once the first circuit is purged, minimally purge other circuits for 30 minutes. Once all well circuits are purged, close all circuit valves and purge piping in building per Section - HVAC WATER TREATMENT CLEANING, FILLING AND PURGING.
- 7.7 Flow rates shall be compared to calculated values to assure that there is no blockage or kinking of any pipe. Submit written verification of compliance.
- 7.8 A minimum velocity of 3 ft/sec in each piping section must be maintained until all air is removed. The system shall also be forward and reversed to remove all debris. Purging of one wellfield row shall be witnessed by the Design Team, Owner, Mechanical Contractor, General Contractor and

the Test and Balance Contractor. The Test and Balance Contractor shall confirm the minimum velocities are obtained during the purging process and shall also measure supply and return pressures. The Contractor shall provide P/T plugs as required by the Test and Balance Contractor. The Contractor shall provide all means and methods necessary to ensure minimum velocities are obtained. After one test is confirmed, the other wellfield rows shall be tested utilizing the same procedure. The Test and Balance Contractor shall confirm all minimum circuit, flow rates are obtained for all wellfield piping.

- 7.9 Final purging of air from the entire building loop and wellfield loop shall be performed by the wellfield purging contractor so that air in the building will not be transferred with the wellfield. Coordinate with the Mechanical Contractor.
- 7.10 Refer to UM series for additional information.

#### PART 8 – HORIZONTAL PIPING SYSTEMS:

- 8.1 Refer to Section EXCAVATION, TRENCHING, BACKFILLING AND GRADING for additional requirements.
- 8.2 Sharp bending of pipe around trench corners shall be prevented by using a shovel to round corners, or by installing an appropriate elbow fitting. Manufacturer's procedures shall be followed.
- 8.3 Backfilling procedure will include prevention of any sharp-edged rocks from coming into contact with the pipe by removal of the rocks before backfilling. Refer to details on the plans. Clods resulting from use of a backhoe shall be broken so as not to form air pockets around the pipe which will reduce heat conduction between the earth and the pipe. The flow of backfill soil must be controlled to prevent bridging and the formation of air pockets. Several slow passes with an angled backfill blade are required. Flooding is required to assure removal of air pockets. Minimum bury depth of piping shall be 36" to top of pipe.
- 8.4 Horizontal return bends must be backfilled by hand to properly support the pipes and prevent kinking.
- 8.5 Install continuous tracer wires on each wellfield circuit in and out of the building. Provide an additional 36" of coiled tracer wire on each end and attach in building at each circuit riser. Perform tracer wire testing for all tracer wires in conjunction with the Owner/Engineer – this is a condition of acceptance and closeout.

#### PART 9 – BORE HOLE AND GROUTING:

- 9.1 The Contractor shall accept the site as-is and is responsible for any and all required steel casings. If an area of voids is encountered, the Contractor shall either fill or re-drill wells in an approved area and extend piping to them. No night drilling will be allowed.
- 9.1.1 Test well bore data may not be available before time of bid. Geothermal and drilling contractors shall be familiar with the area, including the possibility of Karst conditions, and include in the project the appropriate means and methods, including drilling techniques (mud rotary, air rotary,

or other drilling type) and methods as required, to provide the geothermal heat exchangers which utilize 1-1/4" DR9 HDPE piping.

- 9.2 The Contractor shall bore wells of a sufficient diameter to allow installation of the piping and U-bend and a 1-1/4" (minimum) HDPE tremie pipe for grout installation but shall be no less than 6"- 6 1/2".
- 9.3 Bore holes shall be grouted to ensure good heat transfer. Local and state laws and regulations for grouting and backfilling shall be followed. See IGSHPA Grouting Procedures Manual for detailed grouting procedures.
- 9.4 Vertical bores shall be drilled to sufficient depths to ensure that the entire length of U-tube is inserted. This may require the bore to be drilled several feet deeper than the U-tube length.
- 9.5 All U-tube joints shall be visually inspected for integrity as specified by the pipe manufacturer (alignment of joints, proper bead roll-back) before insertion into the bore hole.
- 9.6 The bore hole annulus shall be completely grouted to ensure there are no air voids and to ensure there is consistent contact between the vertical piping and the bore hole formation. This will require the bore annulus to be filled with grout from the bottom to the top with a "tremie" tube.
- 9.7 The entire bore shall be grouted with a thermally enhanced grout mixture with a thermal conductivity of 1.00 Btu/hr-ft-°F. Grout shall be GeoPro Thermal Grout Lite 100 bentonite mixture or approved equal. Mixture shall be field mixed in strict accordance with manufacturer's recommendations. Grout mixture shall be mechanically pumped with a positive displacement pump into bore hole from bottom to top utilizing a tremie tube.
- 9.8 Through the course of the project, sample grout specimens shall be randomly (chosen by Engineer or Owner's Testing Agent) taken of the mixed grouting material by this Contractor for 10% of the vertical bores. An analysis shall be performed by the grout manufacturer to verify proper thermal performance and grout mixture. This Contractor shall submit these reports to the Owner, Architect and Engineer to verify compliance with the installation specifications.
- 9.9 Contractor shall calculate the required grout for the wells based on actual bore diameter and include a submittal for the quantity of grout provided (field measured) for each well and provide tabulation of gallons/cubic feet of grout utilized for each well.
- 9.10 Contractor shall make the local fire chief aware of drilling activity that is to take place on site. Contractor shall share expected dates and daily drilling times with the fire chief. These plans shall be shared with the local authority a minimum of two weeks prior to the beginning of drilling.

#### PART 10 – GEOTHERMAL VAULT:

- 10.1 The vault shall pre-cast concrete and tested prior to shipping to jobsite. Refer to the vault detail on the drawings for further construction requirements and details.
- 10.2 Walls and top shall be 6" thick with 1/2" rebar 12" on center in both directions. The bottom shall be 4" thick with 1/2" rebar 12" on center in both directions.

- 10.3 The exterior of the vault shall be sealed with a water proof membrane or coating. Reference Specification Section "COLD FLUID-APPLIED WATERPROOFING" for other requirements.
- 10.4 Provide a stainless steel or aluminum access hatch USF fabrication, APD or approved equal. The hatch shall be mounted in a concrete extension collars. Hatch shall be set 3" above finish grade and dirt mounded to prevent run-off from pooling at the cover.
- 10.5 Provide an aluminum ladder for access. Refer to the detail on the drawings for mounting requirements.
- 10.6 INTERNAL PIPING: Shall be as previously specified. The vault piping shall be constructed in an offset, over and under, model for supply and return lines. All joints shall be heat fused. The entire piping system shall be tested using 150 psi air. The main supply and return pipe shall be shipped with cap butt welded to pipe. All pipe penetrating the vault walls shall be DR 11 and grouted to be water tight.
- 10.7 P/T PLUGS: Shall be constructed of solid brass and have a dual seal core of Nordel, with a 350°F rating for water. Plugs shall be rated zero leakage for vacuum to 1000 psig and shall be capable of receiving a pressure or temperature probe. Install at the inlet and outlet of each circuit.
- 10.8 BUTTERFLY VALVE: Shall be constructed of a cast iron body, 416 stainless steel stem with a lever shut off system. Refer to Section VALVES for all valve requirements. Install for each circuit supply and return.
- 10.9 90° ELBOWS: Shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.
- 10.10 BRANCH AND SERVICE SADDLES: Shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.
- 10.11 INSTALLATION: The vault shall be lowered into a pit of sufficient depth with a 6" bed of #57 gravel. Once the vault is in place, the vault shall be anchored and sufficient back-fill put in place.
- 10.12 Coordinate power / lighting requirements with Electrical Contractor.

**PART 11 – ADDITIONAL INSTALLATION REQUIREMENTS:**

- 11.1 Underground land survey of the entire geothermal wellfield system per COMMON WORK RESULTS FOR HVAC. This shall include all horizontal piping, vertical bore locations and dimension from above grade fixed benchmarks. The underground survey shall be included in the closeout documentation.
- 11.2 Dust Control: The Contractor shall be responsible for and shall provide dust control. Dust shall not be allowed to leave the construction site boundaries, and furthermore, shall not be allowed to enter the building or accumulate on the building exterior. When needed to meet these requirements, the Contractor shall provide and operate a mechanical dust collection system to control dust at the source. Mechanical dust collection system shall consist of collection hood at the source ducted to a dust collector which separates dust from the airstream. Dust shall be

collected into sealed containers for disposal by the Contractor. Water spraying may be used but shall not be considered a substitute for mechanical dust collection at the source when required.

- 11.3 Surface Water / Mud / Slurry Control: The Contractor shall be responsible for and shall provide control of all ground flowing fluids resulting from drilling operations. The Contractor shall erect silt fences or other structures as required to contain drill cuttings, mud, slurry, etc. within the construction site boundaries. In the event this requirement is not met, the Contractor shall provide all remediation measures as required by all authorities having jurisdiction over such events.

## PART 12 – TEST BORES:

- 12.1 Steps shall be taken to drill test wells as soon as possible upon acceptance of the job. These tests will be utilized to determine site geological and thermal conditions to confirm current wellfield design is sufficient.

## 12.2 SUMMARY

- A. Section includes the furnishing of all equipment, materials and labor reasonably incidental for the complete installation of two (2) closed-loop ground heat exchanger test bores with one (1) bore being tested.
- B. Work shall be conducted in accordance with the requirements of this Section.
- C. The Contractor is responsible for securing all required drilling permits in the name of the Owner. The Contractor shall pay for all permitting costs.
- D. As part of the bid, the Contractor is required to break out unitary pricing (\$/linear ft.) for casing the bore. Should it be determined necessary to case the bore during the installation, this unitary price will be used.
- E. Scope: Two (2) vertical bores shall be installed according to these specifications. The completed bores shall be located so that it is incorporated into the final ground-loop heat exchanger design. A completed vertical test bore shall consist of the SDR-09 vertical bore with an approved polyethylene u-bend assemble installed to the completed bore depth with an approved grouting material installed in the bore annulus. Vertical bore can be drilled by a mud-rotary drilling rig or by a compressed-air drilling rig whichever is most feasible based on geological conditions. Drilling contractor shall provide a detailed test bore report for each bore. The report shall include the following information:
  - 1. Each formation type encountered (drill log)
  - 2. Each formation depth (in feet)
  - 3. Depth of any significant cracks, fissures or caverns encountered
  - 4. All water bearing ones and if encountered:
    - a. Zone depths
    - b. Estimated flow rate
  - 5. Type of drilling equipment used (i.e. mud-rotary, air-rotary, air-hammer, etc.), and rig model number
  - 6. Bag quantity of drill mud used where applicable
  - 7. Total time to drill the test bore excluding shutdowns to obtain water or mechanical

breakdowns.

8. A completed, signed report shall be supplied immediately at the conclusion of the drilling process.
9. The Work also includes flushing and purging of the test bore piping system. The closed-loop ground heat exchanger consists basically of polyethylene heat fusion joined piping formed into vertical loops, for future connection to the extended range water-source heat pump units to provide an ARI 330 ground source closed-loop heat pump system.
10. Contractor to provide 20'-0" length of 6" steel casing as part of the base bid. Contractor to provide a unit price per linear foot for additional steel casing over the 20'-0" length.

## 12.3 REFERENCES

- A. American Society for Testing and Materials
  1. ASTM D1693 -Standard Test Method for Environmental Stress -Cracking of Ethylene Plastics.
  2. ASTM D2321 -Standard Practice for Underground Installation of Thermoplastic for Sewers and Other Gravity-Flow Applications.
  3. ASTM D2447- Standard Specification for Polyethylene (PE) Plastic Pipe Schedules 40 and 80 Based on Controlled Outside Diameter.
  4. ASTM D2487 -Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
  5. ASTM D2513-OQ -Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
  6. ASTM D2683 -Standard Specification for Socket -Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
  7. ASTM D2837 -Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
  8. ASTM D3035-95 -Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
  9. ASTM D3261 -Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
  10. ASTM D3350 -Standard Specification for Polyethylene Plastic Pipe and Fittings Material.

## 12.4 SUBMITTALS

- A. Shop Drawings: Detailed 1/8-inch scale layout drawings of the closed-loop ground heat exchanger test bores showing all other existing underground utilities and relationship to new proposed bore field for coordination purposes.
- B. Product Data: Submit manufacturer's product data and installation instructions for closed-loop ground heat exchanger piping, materials and products.
- C. Manufacturer's Certificate: Pipe manufacturer shall supply a notarized document confirming compliance with the specifications of this Section.
- D. Warranty: D/L must submit 2-year parts and labor warranty certificate covering all work performed.

## 12.5 CLOSEOUT SUBMITTALS

- A. Project Record Documents: 1/8-inch scale record drawings and dimensions showing exact location of the test bores.

## 12.6 QUALITY ASSURANCE

- A. Perform Work in accordance with South Carolina EPA standards.

## 12.7 QUALIFICATIONS

- A. Contractor: Firms regularly engaged in installation of closed-loop ground heat exchanger, and/or projects of similar scope of the type, material and size required; whose installations have been in satisfactory use in similar service for not less than five years. The contractor shall supply, with the bid, information on past jobs of similar scope. The following information must be supplied:
  - 1. Name of project/customer.
  - 2. Location of project.
  - 3. Customer contact name (reference) with phone numbers.
  - 4. Project designer/engineer.
  - 5. Date of installation.
  - 6. Number of wells.
  - 7. Depth of wells.
  - 8. Grout used.
- B. Manufacturer: Company specializing in manufacturing of closed-loop ground heat exchanger products and tools of the types, material and size required; whose products have been in satisfactory use in similar service for not less than three years.
- C. Installer: The Drilling Contractor shall be licensed in the State of South Carolina. Installers shall have at least two years of successful installation experience on projects with closed-loop ground heat exchanger work and/or projects of similar scope to that required for this project. Drilling Contractor must have experience at mixing and pumping pre-engineered cementitious grout materials with simultaneous placement of the pipe assembly and tremie tube from the bottom of the borehole to the top.
- D. Fabricator must have completed a certification training program offered by the International Ground Source Heat Pump Association (IGSHPA) or approved manufacturers' certification program and shall have at least two years of successful installation experience. The only acceptable method of joining buried plastic pipe system is by heat fusion process. Each ground heat exchanger fabricator must have performed a fusion procedure under direct supervision of an IGSHPA Certified Heat Fusion Technician, an IGSHPA approved manufacturer's certification program or a DOT certified heat fusion technician. Each certified technician must attend a retraining school annually.

## 12.8 PRE-INSTALLATION CONFERENCE

- A. Convene a minimum of one week prior to commencing Work of this Section.

- B. Facility director shall be notified 72 hours prior to commencing with Work of this Section.

#### 12.9 DELIVERY, STORAGE, AND HANDLING

- A. Pipe, fittings and cementitious grouting material shall be stored on site in designated area that will not interfere with the operations of the Owner.
- B. All pipe fittings are to be sealed to prevent debris, rodents and other foreign material from entering the piping system.
- C. Palletized cementitious grouting materials are to be protected from the weather with a protective cover.
- D. Topsoil shall not be muddy or frozen.

#### 12.10 FIELD MEASUREMENTS

- A. It is the contractor's responsibility to call 811 to determine if any existing underground utilities are located in the proposed test bore site. The Contractor will coordinate with the Owner or Owner's representative to locate any "Customer/Owner" underground utilities not covered by 811. If any "marked" or located underground utilities are damaged during the test bore operation, it will be the Contractor's responsibility to properly repair and return the utility to service.
- B. Ensure the proper site protection is in place for the moving, setting up, operating and removal of the drill rig and other support vehicles or equipment, including protection of curbs and sidewalks, protection of existing trees, shrubs and lawn. Contractor will inform the Owner of any obstacles to the drilling operation before actions are taken to remove obstacles.

#### 12.11 WARRANTY

- A. Furnish minimum twenty-five-year warranty for piping.

#### 12.12 EXAMINATION

- A. Examine areas and conditions under which ground heat exchanger test bore system is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to owner/engineer's recommendations.
- B. The Contractor shall provide temporary water tanks and temporary electrical power as may be required for completion of work.
- C. A water supply to fill temporary storage tanks will not be made available by the Owner.



## 12.13 INSTALLATION

### A. Loop Insertion and Grouting

1. Drill borehole in accordance with local, State or Federal requirements. Follow all requirements for borehole drilling as prescribed by the State of South Carolina. The contractor will be responsible for receiving permission in writing from the State of South Carolina prior to proceeding and shall be responsible for maintaining any drilling logs that may be required.
  - a. The Contractor shall provide a written description (drill log) of the subsurface geology encountered during the drilling operation by a visual inspection of the drill cuttings. Information provided shall include: description of drill rig type and drill bit, drilling rates in feet per minute and types of formations. The Contractor shall provide this information for each change in geology for the entire depth of the bore hole and record the changes on the test bore report worksheet.
  - b. The Contractor shall advise the Owner/Engineer immediately in writing of the presence and depths of water, cavernous formations or any adverse drilling condition requiring casing of the bore hole. The contractor shall stop drilling operations until a response is received.
2. The borehole shall be clean and of a maximum diameter listed on the test bore report worksheet to facilitate the installation of the u-bend assembly and a tremie pipe. Care shall be taken so as not to stretch, crush, cut, or kink the pipe during installation.
3. Immediately prior to being placed in the borehole, the u-bend assembly shall be flow tested to ensure that there are no kinks, bends or pinches. The test shall consist of forcing clean water into one end of the assembly, and visually inspecting the discharge. If damage or an obstruction exists, that loop shall not be used.
4. If the driller has drilled deeper than indicated on the test bore report worksheet, special precautions shall be taken so that the sealed pipe ends do not "drop" into the open borehole below graded surface. If a buoyant condition exists, the u-bend shall be staked and tied at the surface to prevent the assembly from "floating" out of the bore prior to the "setting" of the cementitious-based grout.
5. Prior to grouting, the u-bend assembly shall be pressurized with water to achieve a minimum internal pressure of 50 psi, and the ends shall be temporarily plugged to maintain this pressure. To prevent the collapse of the pipe resulting from the external force created by the grout's hydrostatic pressure, the pressure in the u-bend assembly shall be maintained until the grout has set.
6. Since some settling may occur after initial placement of the grout material, the installer shall monitor each test borehole and continue adding grout as required to bring the grout level up to the trench grade.
7. Borehole locations shall be individually surveyed after drilling is complete. The survey shall locate the test boreholes accurately from one or more known local survey benchmarks. The contractor shall furnish the Engineer/Owner a drawing indicating the test borehole locations
8. The contractor shall provide temporary security measures to protect the test bore and thermal conductivity testing equipment from vandalism until testing is complete. The Owner takes no responsibility for damage to or theft of Contractor's equipment while said equipment is on site.

9. Following completion of thermal conductivity testing, the Contractor shall flush and seal the heat exchanger piping. The loop shall be no higher than 1-foot above grade.
10. At the conclusion of drilling operations, the Contractor shall remove all drill cutting and trash from the site.
11. The Contractor shall provide temporary metallic enclosure left at or above grade for protecting the heat exchanger piping. A dimensioned "as-drilled" location plan has to be included in the final report.

#### 12.14 ELAPSED TIME BEFORE TESTING

- A. AIR ROTARY DRILLING: A minimum delay of five days between loop grouting and testing is required.
- B. MUD ROTARY DRILLING: A minimum delay of three days between loop grouting and testing is required.

#### 12.15 TESTING AND DOCUMENTATION

- A. Testing is required on only one (1) borehole.
- B. The Contractor shall insulate the supply and return piping between the bore hole piping and the thermal conductivity test and the exposed heat exchanger pipes above grade to ensure proper results.
- C. Initial Ground Temperature shall be obtained by measuring and recording the loop temperature as the water returns from the test loop before start-up of the conductivity test.
- D. Bore Thermal Conductivity: The Contractor shall utilize the in-situ testing equipment and methodology of an independent testing agency (in strict compliance with the recommendations of IGSHPA) to conduct a thermal conductivity of the completed geothermal test bore. The thermal conductivity of the grout shall be established using a constant hot water source, which will simulate a load by adding a controlled amount of heat to the bore piping water. The heat flux rate shall be 15 to 25 Watts/foot of bore hole depth as that is the expected peak load on the heat exchanger U-Bend. In order to avoid potential power quality problems or power interruptions, the use of a portable generator is required (10 KW minimum). The contractor shall trend the heat transfer of the test bore fluid over a period of 48 hours at 5-minute intervals and provide graphs showing temperature versus time and temperature versus natural log of time to provide the actual thermal conductivity value and thermal diffusivity values. The process used shall be approved by the engineer prior to commencement of testing.
  1. Equipment required for the test are the following:
    - a. Ground heat exchanger in place (grouted)
    - b. Constant hot water source
    - c. Data acquisition system to measure and record
      - 1) Temperature in & temperature out
      - 2) Flow rate
      - 3) Volts and Amps or Watts

2. The test procedure to do the in-situ tests is outlined below.
  - a. Locate in-situ trailer near well bore to minimize above ground pipe exposure.
  - b. Flush loop to remove all debris, cap and set overnight, if possible, to obtain the most accurate ground temperature.
  - c. Connect ground loop to trailer.
  - d. Insulate loop leads to trailer to reduce temperature bias.
  - e. Finish filling loop and in-situ system with water.
  - f. Start data acquisition system, name the data file, adjust data recording rate to desired value, show the desired variables on screen in graph and digital form, begin recording data from the initial circulation.
  - g. Turn on pump and circulate the water for 15 to 30 minutes to obtain an average ground temperature. Circulate water at a high rate to flush the system, to eliminate air in the system. Adjust valve to maintain 10 to 15 psi pressure on the system. Minimize break-out if there is some air left in the lines by having a higher system pressure.
  - h. Adjust the flow rate at the test rate depending on the loop size. Make certain that the flow is turbulent, i.e. 6.0 gpm for 1-1/4" pipe will provide high Reynolds Number and stable flow.
  - i. Turn on the heaters to the desired wattage value.
  - j. Monitor screen for any anomalies in the data and periodically check for leaks in the pipe connections. Bleed air from the system as necessary and recharge from the water reservoir if necessary. Minimize any addition of water to the system after the test has begun.
  - k. When the temperature versus time curve begins to flatten out after a period of eighteen to twenty hours shut the heaters off and allow the temperature to decay for a period of time. If a qualitative heat dissipation rate is desired, then run the decay period until the loop temperature approaches the original ground temperature.
  - l. Shut the pump off and then log off the data acquisition system, making sure the file is closed and the data is saved. Transfer the data from the hard drive to a floppy diskette and provide a copy to engineer.
  - m. Remove insulation from the lines and disconnect the loop lines from the trailer and cap.
- E. Grout Permeability: The grout mixture shall exhibit a nominal bulk grout permeability of 10-8 cm/second by using the "Falling-Head Method" (defined in the United States Army Corp of Engineers' Civil Engineering Manual No. EM 1110-2-1906, "Laboratory Soils Testing") as recommended by the U.S. Environmental Protection Agency. The average grout/pipe system nominal permeability shall be determined by using an experimental set-up as outlined in ASTM D 5084-90, and shall have a maximum nominal permeability rate of 1x 10-5 cm/sec.
- F. The Contractor shall document in writing on the test bore report worksheet and final report, formation thermal conductivity and the formation thermal diffusivity.
- G. Final Report shall be organized in a single document including the test bore report worksheets and three copies shall be submitted to the Project Engineer.

## 12.16 FIELD QUALITY CONTROL

- A. Before backfilling the test bores, they shall be flushed and purged of air and flow tested to ensure all portions of the closed-loop ground heat exchanger test bores are properly flowing. A portable temporary purging unit shall be utilized and shall consist of the following:
  - 1. Purge pump -high volume and high head.
  - 2. Open reservoir.
  - 3. Filter assembly.
  - 4. Connecting piping.
  - 5. Connecting hoses.
- B. Using the purging unit described above, flush and purge each test bore free of air, dirt and debris. A minimum velocity of 2 feet second in each piping section must be maintained for a minimum of fifteen minutes to remove all air. A change of more than 1 inch in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system. After the flushing and purging operation with the supply and return lines, the pipe shall be capped and sealed at a point two feet below grade with an identifying marker at least one-foot above grade indicating the depth of the pipes.

## 12.17 FINISH GRADE PREPARATION

- A. Perform all finish grading necessary to bring the site back to its original elevation. Finish grading shall consist of using screened topsoil brought to the site by the test bore contractor.
- B. After completion and approval of finish grading, remove any excess topsoil from site.

END OF SECTION 232113.33

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## SECTION 232123 – HYDRONIC PUMPS

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard. Motors to be high efficiency type. Refer to Specification Section – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

#### 1.2 SCOPE

- A. Pumps shall be factory tested, cleaned and painted prior to shipment. Size, type, capacity and electrical characteristics are listed in the pump schedule.
- B. Insofar as possible, all pumps shall be by the same manufacturer.

### PART 2 – PRODUCTS:

#### 2.1 PERMANENTLY LUBRICATED INLINE PUMPS

- A. Permanently Lubricated Inline Pumps shall be Series PL as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.
- B. The pumps shall be of the horizontal permanently lubricated type, specifically designed for quiet operation. Suitable for 225 degrees F operation at 150 PSIG working pressure.
- C. The pumps shall have a solid high-strength alloy steel shaft supported by XL11 permanently lubricated sealed precision bearings. Bearings are to be permanently oil lubricated. Pump shaft shall connect to a non-metallic noryl impeller.
- D. Pump shall have integral stainless steel face plate and double sided stainless steel neck rings for increased life and seasonal start-up capabilities.
- E. Pump volute shall be of cast bronze. The connection style on bronze pumps shall be flanged with isolation valves.
- F. The motor shall be isolated from circulating fluid through use of a carbon/silicone seal attached on a stainless steel shaft sleeve.
- G. Motors shall be of an Open Drip-Proof design and shall be non-overloading at any point on the pump curve. Motors shall be UL and CSA listed.

- H. Pump shall be of a maintenance free design and be capable of operating in variable speed (varying voltage) applications.

## 2.2 CLOSED COUPLED INLINE PUMPS

- A. Closed Coupled Inline Pump shall be Series 60 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.
- B. The pumps shall be of a vertical or horizontal installation type specifically designed for quiet operation. Suitable for 225° F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, all bronze construction. The pump internals shall be capable of being serviced without disturbing piping connections.
- C. The pumps shall have a solid SAE1045 steel shaft that is integral to the motor. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.
- D. The motor bearings shall support the shaft via heavy-duty grease lubricated ball bearings.
- E. Pump shall be equipped with a mechanical seal assembly. Seal assembly shall have a brass housing, BUNA bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.
- F. Pump shaft shall connect to a brass impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.
- G. Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.
- H. Pump volute shall be of cast iron design for heating systems or cast brass for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles.
- I. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with the closed coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
- J. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.
- K. Each pump shall be factory tested and name-plated before shipment.
- L. Pumps shall conform to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR).

## 2.3 END SUCTION BASE MOUNTED PUMPS

- A. End Suction Base Mounted Pumps shall be Series 1510 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

- B. Pumps shall be base mounted, single stage, end suction design with a foot mounted volute to allow servicing of the impeller and bearing assembly without disturbing piping connection. Pump volute shall be Class 30 cast iron with integrally cast pedestal support feet. The impeller shall be cast bronze enclosed type, dynamically balanced, keyed to the shaft and secured by a locking capscrew.
- C. The liquid cavity shall be sealed off at the pump shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225°F. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal.
- D. Baseplate shall be of structural steel or fabricated steel channel with fully enclosed sides and ends, and securely welded cross members. Grouting area shall be fully open. A flexible type, center dropout design coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor. Coupler shall be shielded by a coupler guard securely fastened to the base. Coupler shall allow for removal of pump's wetted end without disturbing pump volute or movement of the pump's motor and electrical connections.
- E. Provide all pumps with neoprene couplers. EPDM shall not be acceptable.
- F. High efficiency motor shall meet NEMA specifications and shall be of the size, voltage and enclosure called for on the plans. Pump and motor shall be factory aligned, and shall be realigned by contractor after installation. Each pump shall be factory tested per Hydraulic Institute standards. It shall then be thoroughly cleaned and painted with at least one coat of high grade machinery enamel prior to shipment.
- G. Provide shaft guard with slotted window. Guard to be removable. Guard to meet ANSI B15.1, Section 8 and OSHA 1910.219 requirements.
- H. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.
- I. Comply with pump and coupling manufacturers' written instructions.
- J. A qualified representative of the pump supplier shall perform the pump alignment prior to start-up of any base mounted separately coupled pump. Adjust alignment of pump and motor shafts for angular and parallel alignment by 1 of 2 methods specified in the H.I.'s Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance."
- K. After alignment is correct, tighten foundation bolts evenly but not too firmly. Fill base plate completely with non-shrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.
- L. Alignment Tolerances: According to manufacturer's recommendations, but no more than  $\pm .005"$  in the parallel and angular planes. Provide written report to Engineer and Owner from pump supplier indicating alignment procedure and readings from each pump installation.

## PART 3 – EXECUTION:

### 3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PUMP INSTALLATION

- A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- C. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases.
  - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
  - 2. Construct bases to withstand, without damage to equipment, seismic force required by code.
  - 3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of base-mounted pumps unless otherwise indicated or unless required for seismic-anchor support.
  - 4. Minimum Compressive Strength: 5000 psi at 28 days.

### 3.3 ALIGNMENT

- A. Engage a factory-authorized service representative to perform alignment service.
- B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.



### 3.4 CONNECTIONS

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install check, shutoff, and throttling valves; check valve and throttling valve with memory stop; or triple-duty valve as detailed on discharge side of pumps as detailed.
- E. Install Y-type strainer or suction diffuser as detailed and shutoff valve on suction side of pumps.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
- H. Install check valve and gate or ball valve on each condensate pump unit discharge.
- I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### 3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Check piping connections for tightness.
  - 3. Clean strainers on suction piping.
  - 4. Perform the following startup checks for each pump before starting:
    - a. Verify bearing lubrication.
    - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    - c. Verify that pump is rotating in the correct direction.
  - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
  - 6. Start motor.
  - 7. Open discharge valve slowly.

3.6 DEMONSTRATION

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

END OF SECTION 230100

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## SECTION 232500 – HVAC WATER TREATMENT, CLEANING FILLING, AND PURGING

### PART 1 – GENERAL:

- 1.1 The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- 1.2 Review the Specification Section – COMMON WORK RESULTS FOR HVAC. List and provide all documentations called for therein.
- 1.3 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected.
- 1.4 Provide a water treatment program for the closed loop piping systems. It is the Contractor's responsibility to contact the engineer 2 weeks in advance to any treatments performed on the systems. It is the Engineer's discretion whether or not this process should be monitored after notification.
- 1.5 A pre-installation meeting shall be held with the Owner, Architect, Engineer, General Contractor, Mechanical Contractor, Pipe Fitter Foreman, Geothermal Contractor and Chemical Treatment Contractor to discuss goals and expectations for cleaning, flushing, purging and chemical treatment.
- 1.6 Chemicals, equipment, testing services, and chemical application shall be supplied by a single water treatment company for undivided responsibility. The water treatment company shall be a recognized specialist, active in the field of commercial/industrial water treatment for at least 5 years. The water treatment company shall have regional water analysis laboratories, service department, and full-time representatives located within the trading area of the job site or facility.
- 1.7 Furnish initial supply of the closed loop chemicals for each system. This contractor shall retest the systems after 3, 6 and 12 months to verify the proper dosage is in each system. Provide all closed loop chemicals and anti-freeze for the first year. Each system's water shall be tested for proper chemical parameters, clarity, and biological activity. If needed, provide chemical addition. Provide any laboratory and technical assistance required to achieve a successful program.
- 1.8 As a condition of acceptance and project closeout, a summary of water quality and treatment shall be provided in writing to the Owner and/or Engineer after the water treatment services have been completed. The closeout documentation shall include dates for warranty testing.
- 1.9 Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.10 Water Quality Minimum Performance Requirements:

- Closed hydronic systems shall maintain a pH value within 9 – 10.5.
- Total Aerobic Plate Count - Maintain a maximum value of 1000 organisms/ml.
- Total Anaerobic Plate Count - Maintain a maximum value of 100 organisms/ml.
- Nitrate Reducers - Maintain a maximum value of 100 organisms/ml.
- Sulfate reducers - Maintain a maximum value of 0 organisms/ml.
- Iron Bacteria - Maintain a maximum value of 0 organisms/ml.

PART 2 – CLEANING AND FLUSHING OF HYDRONIC PIPING:

2.1 This project consists of the following Hydronic Piping Loops:

- Chilled/Hot Water (2-pipe) Hydronic System
- Geothermal Heat Pump Water System (Interior/Exterior)

2.2 There are several precautions which must be observed during its installation. This contractor is advised to read all of the manufacturer's instructions prior to commencing the installation. This cleaning and flushing of the systems must be accomplished. Refer to Specification Section HVAC EQUIPMENT for geothermal system requirements.

2.3 All water circulating systems for the project shall be thoroughly cleaned before placing in operation to rid the system of dirt, piping compound, mill scale, oil and any and all other material foreign to the water. During construction, extreme care shall be exercised to prevent all dirt and other foreign matter from entering the pipe or other parts of the system. Pipe stored on the project shall have the open ends capped and equipment shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined and all dirt removed.

2.4 After each piping system is complete: (1) the Contractor shall first fill the piping loops and all runouts with clear water. The loop water shall be circulated for one hour with make-up water open and central drains open to accomplish initial flushing of the system. (2) After initial flushing, the individual terminal devices and coils may be connected permanently to the supply and return runouts conditions and then add trisodium phosphate in an aqueous solution to the system at the proportion of one pound per fifty gallons of water in the system. (4) After the system is filled with this solution, the system water shall be brought up to 95 degrees F temperature and allowed to circulate for two hours. (Equipment to be bypassed.) (5) The Chemical Treatment Contractor shall be given notice by the Contractor of scheduling this cleaning and, if the Engineer's representative deems it necessary, the operation shall be repeated. (6) After the system has been completely cleaned as specified herein, it shall be tested by litmus paper or other dependable method and shall be left on the slightly alkaline side (PH = 7.5 plus or minus). (7) If the system is found to be still on the acid side, the cleaning by use of Trisodium Phosphate shall be repeated. (8) After achieving required pH, close bypasses and circulate through equipment. (9) After the cleaning and flushing is complete, and approved, the Contractor shall provide the proper water treatment for the system.

### PART 3 – CLOSED LOOP CHEMICAL TREATMENT:

- 3.1 Provide a 3/4" valved and capped port for injection of the closed loop chemicals into the system. Also, provide a bypass chemical pot feeder for each loop.
- 3.2 After the system is complete it shall be thoroughly cleaned before placing in operation to rid the system of dirt, biological contamination, piping compound, loose mill scale, oil, and any and all other material foreign to the water as previously specified.
- 3.3 Before chemical cleaning and sterilization of the entire system, the field and hydronic loop and mains shall be individually flushed and purged until free of dirt, debris, and air. During the flushing/purging and chemical cleaning processes the supply and return run-outs shall be temporarily placed in bypass operation. See SYSTEM FILLING & PURGING PLAN for additional information.
- 3.4 After chemical cleaning, the entire system shall be sterilized with a biocide added at recommended dosage to effectively kill any present microorganisms. Add glutaraldehyde to achieve 60 – 200 ppm of active ingredient or isothiazoline to achieve 10 – 13 ppm active. Do not flush biocide from system. Corrosion inhibitors shall be installed in closed loop systems containing metal piping, fittings, accessories, etc.
- 3.5 A bacteria analysis shall be performed to ascertain biological cleanliness of system. If bacteria counts are above set parameters, then sterilization process shall be repeated until bacteria counts are at or below acceptable levels. Microbiological limits are listed under “Water Quality Minimum Performance Requirements” elsewhere in this Specification Section.
- 3.6 Within 48 hours of the completion of the sterilization implement a water treatment program to passivate all metal surfaces.

### PART 4 – SYSTEM FILLING & PURGING PLAN:

- 4.1 All piping circuits originate from mechanical pump room. System consists of heat pump mains and branch circuits plus nine well field circuits.
  - System mains: 8"
  - Well field circuits: 3".
- 4.2 Temporarily connect the supply and return piping in the mechanical pump room at the purge valve location and close main line valve to isolate the building from the well field. Note that central filter pump can be used, after initial purging and for maintenance, as the purge pump (Well field in reverse direction). Refer to drawings for additional information.
- 4.3 The interior piping and the well field shall be purged individually. The building purging pump is capable of purging the interior loop purging after the system has been initially purged.
- 4.4 The system shall be filled under full city water pressure from the HVAC fill station located main mechanical room.
- 4.5 Obtain a minimum flow based on 2 to 3 fps in each circuit as indicated on the plans. Refer to plans for additional information.

- 4.6 Each 3" circuit from the wellfield shall also be purged. 135 GPM minimum required for the 3" circuits with 1 1/4" well field circuits.
- 4.7 This procedure shall be carried out a minimum of three times to ensure entrained air is removed.

END OF SECTION 232500

## SECTION 233113 - METAL DUCTS

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
  - 3. DUCT INSULATION.
  - 4. AIR DUCT ACCESSORIES
  - 5. DIFFUSERS, REGISTERS & GRILLES
  - 6. DEDICATED OUTDOOR-AIR UNITS
  - 7. WATER-SOURCE UNITARY HEAT PUMPS

#### 1.2 SCOPE

- A. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's Duct Manual and Sheet Metal Construction for Low Velocity Ventilating and Air Conditioning Systems. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.
- B. Ductwork shall be constructed and installed per the latest edition of the International Mechanical Code.
- C. Ductwork shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.
- D. Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.
- E. Provide a SMACNA duct cleanliness level "C" per the latest SMACNA standards.

## PART 2 – PRODUCTS:

### 2.1 LOW VELOCITY DUCTWORK (Heat pump Supply/Return, and DOAS Exhaust ductwork).

- A. Ductwork, plenums and other appurtenances shall be constructed of one of the following: Steel sheets, zinc coated, Federal Specification 00-S-775, Type I, Class E & ASTM A93-59T with G-90 zinc coating. Aluminum alloy sheets 3003, Federal Specification AA-A-359, Temper H-14.
- B. Ductwork, plenums and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the latest SMACNA 2" W.G. Standard or below table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum.

| <u>Round Diameter</u> | <u>Duct Gauge</u> | <u>Rectangular Width</u> | <u>Duct Gauge</u> |
|-----------------------|-------------------|--------------------------|-------------------|
| 3-12 Inches           | 26 Ga.            | 3-12 inches              | 26 Ga.            |
| 12-18 Inches          | 24 Ga.            | 13-30 inches             | 24 Ga.            |
| 19-28 Inches          | 22 Ga.            | 31-54 inches             | 22 Ga.            |
| 29-36 Inches          | 20 Ga.            | 55-84 inches             | 20 Ga.            |
| 37-52 Inches          | 18 Ga.            | 85 inches and up         | 18 Ga.            |

- C. All ductwork connections, fittings, joints, etc., including longitudinal and transverse joints, seams and connections shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15"wg. Apply per manufacturer's recommendations. Contractors shall insure no exposed sharp edges or burrs on ductwork.
- D. Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.
- E. All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.
- F. Cross-break all ducts where either cross sectional dimension is 18" or larger.
- G. Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. Duct supports shall not exceed 12 ft intervals. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from purlins or other weak structural members where no additional weight may be applied. If in doubt, consult the Structural Engineer.
- H. Double turning vanes shall be installed in square turns and/or where indicated.
- I. INSULATED FLEXIBLE AIR DUCT: Thermaflex G-KM or equal. Flexible air duct shall be two (2) inch thick fiberglass insulation with CPE liner permanently bonded to a coated spring steel wire helix supporting a fiberglass scrim and fiberglass insulating blanket. Flexible air duct shall be listed under UL Standard 181 as a Class I flexible air duct complying with NFPA 90A and 90B. Maximum flame spread = 25 and maximum smoke developed = 50. Minimum



insulating value is R-6.0. Flexible duct shall be used only for GRD runouts and no section shall be more than five feet in length.

## 2.2 HIGH VELOCITY DUCTWORK (DOAS Supply Ductwork)

- A. High velocity ductwork shall be utilized for all supply ductwork between air handling units and VAV/CAV boxes. Provide Eastern Sheet Metal Model "CB" or equal takeoff fitting for each VAV/CAV off high velocity main. Shop or field fabricated takeoffs are not acceptable. Straight tees are not allowed.
- B. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork and manifolds. Drawings shall be available in an electronic format.
- C. All round and oval high velocity ductwork for systems above 1.5" W.G. shall be Eastern Sheet Metal, United McGill or Semco or equal as required by the latest SMACNA 10" W.G. Standard.
- D. Ductwork shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of galvanized steel. Galvanized metal shall be prepped and clean prior to painting. Coordinate with General Contractor. Ductwork shall be constructed of the following minimum gauges:

| <u>Round Diameter</u> | <u>Duct Gauge</u> | <u>Flat Oval Major Axis</u> | <u>Duct Gauge</u> |
|-----------------------|-------------------|-----------------------------|-------------------|
| 3-14 Inches           | 26 Ga.            | 10-24 inches                | 24 Ga.            |
| 15-26 Inches          | 24 Ga.            | 25-48 inches                | 22 Ga.            |
| 27-36 Inches          | 22 Ga.            | 49-71 inches                | 20 Ga.            |
| 37-50 Inches          | 20 Ga.            | 71 inches and up            | 18 Ga.            |
| 52-84 Inches          | 18 Ga.            |                             |                   |

- E. All high velocity duct fittings shall be fabricated by the same manufacturer as the spiral pipe. Contractor or field fabricated fittings shall not be accepted. Duct fittings shall be constructed per the latest SMACNA 10" WG standard with continuous welds. Take-off fittings shall be combination type tees (Eastern Sheet Metal Model "CB" or equal). Straight or angle tees are not acceptable. Fittings shall be constructed of the following minimum gauges:

| <u>Round Diameter</u> | <u>Duct Gauge</u> | <u>Flat Oval Major Axis</u> | <u>Duct Gauge</u> |
|-----------------------|-------------------|-----------------------------|-------------------|
| 3-50 Inches           | 20 Ga.            | 10-36 inches                | 20 Ga.            |
| 52-60 Inches          | 18 Ga.            | 37-60 inches                | 18 Ga.            |
| 61-84 Inches          | 16 Ga.            | 71 inches and up            | 16 Ga.            |

- F. All single wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange on all ductwork greater than 24 inches in size.
- G. Duct dimensions indicated are required inside clear dimensions.
- H. Ductwork shall be installed per the latest SMACNA Medium or High Pressure Manual, whichever is applicable.

- I. All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA. Flat oval ducts shall be installed with 2"x2"x1/4" angles on top and bottom ducts 18" wide and larger. Use 1"x1"x3/16" angles on ducts under 18" wide.

## 2.3 KITCHEN RANGE HOOD EXHAUST DUCT (COMMERCIAL):

- A. Ducts shall be constructed of shall be constructed of 16-gauge carbon steel with liquid-tight continuous weld of all seams and joints. Inside laps on duct joints shall project in a direction against the air flow.
- B. Ducts shall be so constructed and sloped as to provide suitable drainage of grease to a collection point.
- C. Hand holes for inspection and cleaning purposes, equipped with tight fitting sliding or swinging doors and latches, shall be provided in horizontal sections of exhaust ducts. Such openings shall be at the sides of the horizontal run in order to prevent dripping of residue. Spacing of such openings shall not exceed 20 feet and shall be located at all offsets. See drawings for exact locations. Openings shall have a minimum dimension of 12" x 12". Where this is unable to be installed, the opening shall be 12" on one side and large enough to provide access for cleaning and maintenance. The opening cannot be closer than 1" from the edge of the duct.
- D. At the base of each vertical riser, a residue trap shall be provided with provisions for cleanout.
- E. The contractor shall install the grease ductwork with a UL listed field-applied grease duct enclosure system in accordance with ASTM E2336, similar to 3M Fire Barrier Duct Wrap 615+, to achieve a 2-hour fire rating and zero clearance to combustibles. The duct wrap shall extend from the collar of the hood to where the ductwork exits the building onto the roof. Where grease duct is not wrapped on the roof, the ductwork shall maintain an 18" clearance to combustibles.
- F. Shop drawings of the kitchen rangehood exhaust ductwork shall be made and submitted to the appropriate reviewing agency. Any fees associated with this submittal shall be borne by this Contractor.

## 2.4 EXPOSED ROUND DUCTWORK

- A. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork, and manifolds. Drawings shall be available in an electronic format.
- B. Furnish and install where indicated double wall duct. The double wall duct shall be Eastern Sheet Metal, United McGill, Semco or approved equivalent. The duct shall have an inner shell, a 1-inch layer of fiberglass insulation and an outer pressure shell.
- C. Ductwork outer shell shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of G90 galvanized steel, 20 gauge, and shall be supported as required with aircraft cables and self-tightening locks. Exposed metal shall be prepped and cleaned prior to painting. Coordinate with

General Contractor. Ductwork shall be constructed as specified in LOW VELOCITY DUCTWORK.

- D. Inner shell for spiral pipe shall be 26 gauge solid galvanized steel, as noted on drawings. Ductwork shall have 3 intermediate reinforcing ribs and be constructed of the minimum gauge specified.
- E. Inner shell for fittings shall be galvanized steel. All fittings shall be manufactured by the same manufacturer as the spiral pipe. Fittings shall be constructed a minimum of 22 Ga.
- F. The fiberglass liner shall have a maximum thermal conductivity (k) factor of 0.27 btu per hour per square foot per degree Fahrenheit per inch thickness at 75 degree F ambient temperature.
- G. All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1-1/2" outer flange and an inner secondary flange which shall keep the inner flange concentric and eliminate inner wall connections. Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

## 2.5 DRYER VENT DUCTWORK

- A. Refer to the drawings for exact duct sizing.
- B. Dryer vent ductwork shall be rigid metal 20-gauge aluminum duct. Duct joints shall be installed so that the male end of the duct points in the direction of the airflow. Joints shall be secured with metal tape (not duct tape). Do not use rivets or screws in the joints or anywhere else in the duct as these will incur lint collection.
- C. Length of concealed rigid metal ducting shall not exceed the allowable length of 35 feet. Deduct 5 feet from the allowable length for every 4" 90 degree elbow and 4" 2.5 feet for every 45 degree fitting. These lengths may vary per local codes and dryer manufacturer's recommendations. Install per 2012 IMC Section 504 Clothes Dryer Exhaust. Provide a complete, working in-line booster fan system, including power, if the maximum allowable duct length is exceeded.
- D. Flexible transition hose connection at the dryer shall be the aluminum flexible duct type. Do not use the plastic or vinyl.
- E. Termination of individual dryer venting shall utilize Seiho SFZC aluminum dryer vent with integral backdraft damper.
- F. Dryer exhaust ductwork shall be wrapped with Kinetics KNM-100ALQ 1" acoustical wrap (or equivalent) from dryer connection to point of discharge on exterior wall. Wrap shall have K value of 0.29 rated for temperature range of -40°F to 220°F. Acoustical wrap sound transmission loss shall meet or exceed the following: 13/16/24/33/43/49 (125/250/500/1K/2K/4K HZ).

## PART 3 – EXECUTION:

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- 3.1 Unless otherwise dimensioned on the drawings, all diffusers, registers and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.
- 3.2 All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15"wg. Apply per manufacturer's recommendations.
- 3.3 The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.
- 3.4 Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.
- 3.5 All fans and other vibrating equipment shall be suspended by independent vibration isolators.
- 3.6 Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.
- 3.7 Low Velocity Ductwork: Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.
- 3.8 The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.
- 3.9 All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.
- 3.10 AIR LEAKAGE TESTING OF THE DUCTWORK SYSTEMS
- A. It is the intent of this section to ensure the ductwork installed has minimal air leakage. Air leakage testing shall be accomplished by an AABC certified company. Refer to the Test & Balance specifications. Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.
- B. Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a

minimum only. The Contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.

- C. All outside and exhaust air sheet metal ductwork associated with the DOAS systems shall be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers, after the round branch air volume damper with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.
- D. A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the Owner, Engineer, Test & Balance Contractor, General Contractor, Mechanical Contractor, Sheet Metal Contractor and Insulation Contractor. At this meeting, the Contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.
- E. It is the intent to test all ductwork. The duct systems which will require testing are as follows:
  - 1. All outside air duct systems.
  - 2. All exhaust air duct systems.
- F. Do not insulate the outside air systems prior to testing.
- G. The maximum allowable outside air leakage rate is 2.5% of the systems design CFM when the ductwork is pressurized to 2.5" WG. Therefore, if a outside air system is tested, and the supply air fan rated capacity is 10,000 CFM, the allowable leakage is 250 CFM. The maximum allowable exhaust air leakage rate is 2.5% of the system design when the ductwork is pressurized to 1.50" WG.
- H. The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
  - 1. All ductwork as described in above paragraphs.
  - 2. Access doors
  - 3. Volume dampers
  - 4. End caps used to seal ducts
  - 5. Fire dampers
- I. If any duct system fails a test, the Contractor shall reseal the system. It shall than be retested until the duct system meets the leakage allotment at no additional cost to the Owner.

END OF SECTION 233113

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## SECTION 233300 - AIR DUCT ACCESSORIES

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
  - 3. METAL DUCTS
  - 4. DIFFUSERS, REGISTERS & GRILLES

#### 1.2 SCOPE OF WORK

- A. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's Duct Manual and Sheet Metal Construction for Low Velocity Ventilating and Air Conditioning Systems. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.
- B. Ductwork accessories shall be constructed and installed per the latest edition of the International Mechanical Code.
- C. Ductwork accessories shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.
- D. Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.
- E. Provide a SMACNA duct cleanliness level "C" per the latest SMACNA standards.

## PART 2 – PRODUCTS:

### 2.1 LOW VELOCITY DUCTWORK ACCESSORIES

- A. Provide a “high efficiency” type take-off with round damper (Flexmaster STOD-B03 or approved equal) for all round duct branches from a rectangular main to a GRD. Refer to the detail on the drawings for all installation requirements.
- B. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.
- C. FLEXIBLE CONNECTORS: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA No. 90A; neoprene coated glass fabric; 20 oz. for low velocity ducts secured with snap lock.
- D. TURNING VANES: Fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.
- E. ACCESS DOORS IN DUCTWORK: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length. Door shall be 2" thick double-wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the purpose of determining position. Access doors shall also be provided on each side of duct coils and downstream side of VAV boxes and CAV boxes.
- F. VOLUME DAMPERS (RECTANGULAR): Ruskin MD35 or Air Balance, Pottorff, rectangular volume dampers. Frames shall be 16 gauge galvanized steel. Blades shall be opposed blade 16 gauge galvanized steel with triple crimped blades on 6" centers. Linkage shall be concealed in jamb. Bearings shall be ½" nylon. Maximum single section size shall be 48" wide and 72" high. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.
- G. VOLUME DAMPERS (ROUND): Ruskin MDRS25 or Air Balance, Pottorff round volume dampers. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 20 gauge steel and 6" long. Damper blades shall be 20 gauge crimped galvanized steel. Axle shall be 3/8"x6" square plated steel. Bearing shall be 3/8" nylon. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.
- H. FIRE DAMPERS: Fire dampers shall be Ruskin 1BD2 1½ hour rating U-215B vertical 1½ hour rating or United Air Type U-255B for a 3 hour vertical rating. Other acceptable manufacturers are Air Balance or Pottorff. Fire dampers shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1½ or 3 hour fire protection rating as required by fire wall. Damper shall have a 165 degrees F fusible link and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for



vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing minimum 20 gauge steel sleeves, angles, other materials, practices required to provide an installation to that utilized by the manufacturer when dampers were tested at UL. Blade and frame thickness shall be a minimum of 24 gauge. Installation shall be in accordance with the damper manufacturer's instructions. The blades shall be out of the air stream. Provide an access door for fire damper reset at all fire damper locations. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

## 2.2 HIGH VELOCITY DUCTWORK ACCESSORIES

- A. FLEXIBLE CONNECTORS: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA No. 90A; neoprene coated glass fabric. Provide flexible connectors at inlet and outlet of air handling equipment to accommodate a minimum of three times the operating pressure of the system.
- B. PRESSURE RELIEF DOORS: Provide a pressure relief door in the supply air ductwork at each air handling unit. It shall be located where shown on the drawings. It shall be sized to relieve the duct air pressure below the rated pressure construction of the ductwork and above the working pressure of the fan. The supply air relief door shall be Ruskin PRD18 or equal. Provide a vacuum relief door in the return air ductwork at each return air fan. It shall be located where shown on the drawings. It shall be sized to relieve the duct vacuum below the rated construction of the ductwork and above the working negative pressure of the fan. The return air relief door shall be Ruskin NRD18 or equal. Automatic fan shutdown upon damper closure shall not be an acceptable protection for either overpressure or vacuum conditions. All duct relief dampers shall be of the automatic resetting type.
- C. ARCHITECTURAL ACCESS DOORS IN CEILINGS OR WALLS: Refer to architectural drawings and specifications.
- D. FIRE DAMPERS: Unless noted otherwise, fire dampers shall be curtain-type dynamic Ruskin D1BD2 1½ hour rating U-215B vertical 1½ hour rating. Other acceptable manufacturers are Air Balance or Pottorff. Fire dampers shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1½ or 3 hour fire protection rating as required by fire wall. Damper shall have a 165 degrees F fusible link and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing minimum 20 gauge steel sleeves, angles, other materials, practices required to provide an installation to that utilized by the manufacturer when dampers were tested at UL. Blade and frame thickness shall be a minimum of 24 gauge. Installation shall be in accordance with the damper manufacturer's instructions. Provide an access door for fire damper reset at all fire damper locations. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements. Where fire dampers penetrate UL 1503 assemblies (See building 3, Level 1 near Catering Pantry 104), utilize Ruskin DFD60 or similar with airfoil blades.

PART 3 – EXECUTION:

- 3.1 Unless otherwise dimensioned on the drawings, all diffusers, registers and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.
- 3.2 All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15"wg. Apply per manufacturer's recommendations.
- 3.3 Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.
- 3.5 The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.
- 3.6 Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.
- 3.7 Double turning vanes shall be installed in square turns and/or where indicated.
- 3.8 Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.
- 3.9 All fans and other vibrating equipment shall be suspended by independent vibration isolators.
- 3.10 Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated.
- 3.11 Low Velocity Ductwork: Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.
- 3.12 The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

- 3.13 All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

END OF SECTION 233300

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## SECTION 233600 – OA VARIABLE AIR VOLUME TERMINAL BOXES

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.
- C. Each Contractor's attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.
- D. Each Contractor's attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

#### 1.2 SCOPE

- A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.
- B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
- C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.
- D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

### PART 2 – PRODUCTS:

- 2.1 ACCEPTABLE MANUFACTURERS: ETI, Trane, Titus, Carrier, JCI/York, Price.

- 2.2 Terminals shall be certified by ARI and bear the ARI 880 seal.
- 2.3 Terminals shall be constructed of not less than 22 gauge galvanized steel, able to withstand a 125 hour salt spray test per ASTM B-117. The terminal casing shall be mechanically assembled (spot-welded casings are not acceptable). Terminal shall include control enclosure and hanger brackets. The terminal shall be provided with a removable bottom access panel.
- 2.4 Casing shall be insulated with ½" thick fiberglass insulation, rated for a maximum air velocity of 5000 f.p.m. Maximum thermal conductivity shall be  $0.24 \text{ (BTU} \cdot \text{in)} / \text{(hr} \cdot \text{ft}^2 \cdot \text{°F)}$ . Insulation must meet all requirements of ASTM C1071 (including C665), UL 181 for erosion, and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A. Raw insulation edges on the discharge of the unit must be covered with metal liner to eliminate flaking of insulation during field duct connections. Simple "buttering" of raw edges with an approved sealant is not acceptable. Insulation shall be covered with scrim backed foil facing. All insulation edges shall be covered with foil or metal nosing. Insulation shall meet ASTM C1136 for mold, mildew, and humidity resistance. All appurtenances including control assemblies and control enclosures, shall not extend beyond the top and bottom of the unit casing. At an inlet velocity of 2000 f.p.m., the static pressure drop across the basic terminal shall not exceed .08" W.G. for all unit sizes.
- 2.5 Additionally, the air terminals shall be double wall insulated, foil faced.
- 2.6 The primary air valve shall consist of a minimum 22 gauge cylindrical body that includes embossment rings for rigidity. The damper blade shall be connected to a solid shaft by means of an integral molded sleeve which does not require screw or bolt fasteners. The shaft shall be manufactured of a low thermal conducting composite material, and include a molded damper position indicator visible from the exterior of the unit. The damper shall pivot in self lubricating bearings. The damper actuator shall be mounted on the exterior of the terminal for ease of service. The valve assembly shall include internal mechanical stops for both full open and closed positions. The damper blade seal shall be secured without use of adhesives. The air valve leakage shall not exceed 1% of maximum inlet rated airflow at 3" W.G. inlet pressure.
- 2.7 The differential pressure airflow sensor shall traverse the duct along two perpendicular diameters. Cylindrically shaped inlets shall utilize the equal cross sectional area or log-linear traverse method. Single axis sensor shall not be acceptable. A minimum of 12 total pressure sensing points shall be utilized. The total pressure inputs shall be averaged using a pressure chamber located at the center of the sensor. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 2.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. The sensor shall develop a differential pressure of 0.03" W.G. at an air velocity of <450 FPM. Brass balancing taps and airflow calibration charts shall be provided for field airflow measurements. Terminal shall have access door for inspection and cleaning.

### PART 3 – EXECUTION:

- 3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

- 3.2 A 100% complete mockup installation shall be required for a typical unit. This mockup shall be inspected/reviewed by the Engineer prior to installation of other units.
- 3.3 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.
- 3.4 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.
- 3.5 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.
- 3.6 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly and O&M staff shall be able to operate the system prior to turnover.
- 3.7 Determine from the Bid Documents the date of completion of this project and insure that equipment delivery schedules can be met so as to allow this completion date to be met.
- 3.8 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative.

END OF SECTION 233600

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## SECTION 233713 - DIFFUSERS, REGISTERS & GRILLES

### PART 1 – GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. The Contractor's attention is directed to the following Plans and the Specification Sections:
  - 1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
  - 2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
  - 3. DUCT INSULATION.
  - 4. METAL DUCTS

### PART 2 – PRODUCTS

#### 2.1 REGISTERS, GRILLES, AND DIFFUSERS

- A. Acceptable R, G & D manufacturers are Krueger, Anemostat, Nailor Industries, Titus and Tuttle & Bailey. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes for specified devices shall be selected by the Architect. Factory color samples shall be submitted with shop drawings. Devices shall be white unless noted otherwise. Aluminized steel devices are not acceptable. Steel devices are not acceptable unless specifically noted otherwise.

- 2.2 Refer to drawings for schedule.

### PART 3 – EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

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

### 3.3 ADJUSTING

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

END OF SECTION 233713

## SECTION 233800 – VENTILATION HOODS

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.
- C. Each Contractor's attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.
- D. Each Contractor's attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.
- E. Each Contractor's attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

#### 1.2 SCOPE

- A. The Contractor shall provide in complete working order kitchen range hood, make up air and exhaust system equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.
- B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
- C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.
- D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

## PART 2 – PRODUCTS:

- 2.1 ACCEPTABLE MANUFACTURERS: Greenheck, Captive Aire or equal.
- 2.2 The Contractor shall submit shop drawings for the kitchen range hood system(s) along with all required supporting documentation and review fees to the Department of Housing, Buildings and Construction.
- 2.3 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved system. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section - ELECTRIC MOTORS, ETC. for additional requirements.
- 2.4 Hood shall be furnished and installed to comply with NFPA-96, IMC Chapter 5 and local/state regulating governing same. Refer to drawings for sizes, locations, etc.
- 2.5 Hoods shall all be constructed of 18 gauge, Type 304 stainless steel and Number 3 finish. Grind and polish all exposed welds. Joints other than welded will not be accepted. All joints shall be internally welded.
- 2.6 Hood shall be furnished complete with all required concentric ductwork, plenums, curbs and controls. The rangehood supply and exhaust duct collars shall each be provided. Provide 8" minimum between supply and exhaust collars.
- 2.7 Provide 16" minimum height insulated roof curb for rangehood exhaust fans. Provide 16" minimum height insulated roof curb for makeup air unit at discharge. Provide equipment rails flashed/counter-flashed into roofing system for rear and middle sections of makeup air unit. Coordinate roof curb requirements with roofing system.
- 2.8 Hoods shall be capable of providing up to 90% of the required make-up air tempered through discharge grilles in the face of the hood.
- 2.9 Hoods shall be equipped with vapor proof fluorescent light fixtures with an average lamp output of 15 watts per foot of hood. Light Fixtures shall be UL-listed, surface-mounted, with lenses sealed vaportight.
- 2.10 TYPE I EXHAUST HOODS – GREASE LADEN VAPORS: Hood and controller by food service consultant.
- 2.11 EXHAUST FANS:
  - A. Acceptable Manufacturers: Twin City, Greenheck, Cook, Captiveaire.
  - B. Units shall be UL 76 certified for grease removal and selected in conjunction with the hoods.
  - C. Provide with totally enclosed motor and grease box.
  - D. Disconnect Switch: Where scheduled, a NEMA 3R disconnect switch shall be supplied with wiring leading from the motor to the junction box (TEFC motors).

- E. Accessories: 16" roof curb, curb hinge with retaining chain, and aluminum bird screen. Refer to the drawings for additional requirements.
- F. Provide with four (4) sets of belts for the Owner's use upon Substantial Completion.

## 2.12 ELECTRIC MAKEUP AIR UNIT:

- A. Acceptable Manufacturers: K-Tech, DuoAire, Trane, Reznor, or Greenheck.
- B. The roof mounted make-up air unit including all components, shall be fully factory built, assembled, tested and wired in accordance with NEC #70. Complete housing constructed of 20 gauge aluminized steel painted with a weatherproof production enamel over a primed surface.
- C. Centrifugal supply fan with forward curved blades and adjustable belt drive with motor, pulleys and belts. Fans shall be statically and dynamically balanced with double inlet. An access interlock switch shall be installed in the blower compartment and will disengage the blower upon removing the service panel. An override shall be incorporated into the interlock switch for serviceability. Motorized inlet-air dampers shall be provided with all operating controls installed.
- D. For the makeup air unit, provide a factory wired control panel to the voltage specified, mounted in a weatherproof box, shall contain in addition to terminals and wiring for the above, magnetic starters with three leg overload and disconnect switches for supply and exhaust fans and control transformer. All electrical work shall be in accordance with system design and in strict adherence to NEC #70 and other applicable codes. Electrical cabinet shall be isolated from the air stream with a non-removable access panel interior to the outer service panel. Motor and control wiring shall be harnessed with terminal block connections. Provide with fan motor starter and power disconnect switch for the entire unit.
- E. Air Filter: Filter section for supply air with bird screen. Cleanable, sized by the manufacturer, aluminum mesh filters shall be provided in an easy access housing and slipframe.

## PART 3 – EXECUTION:

- 3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.
- 3.2 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.
- 3.3 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.
- 3.4 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

- 3.5 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly and O&M staff shall be able to operate the system prior to turnover.
- 3.6 Determine from the Bid Documents the date of completion of this project and insure that equipment delivery schedules can be met so as to allow this completion date to be met.
- 3.7 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section COMMON WORK RESULTS FOR HVAC. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.
- 3.8 BALANCING: Hoods supply and exhaust fan shall have the final air balance supervised by factory authorized personnel to obtain maximum performance. Submit air balance report to engineer stating CFM of exhaust and supply fans.
- 3.9 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for additional requirements.
- 3.10 DUCT LEAKAGE TESTING:
- A. Prior to the use or concealment of any portion of the duct system, a duct leakage test shall be performed in the presence of the Code Official. Ducts shall be considered concealed where installed in shafts or covered by coatings or wraps that prevent the ductwork from being visually inspected on all sides. The Contractor shall be responsible to provide the necessary equipment and perform the duct leakage test. A light test or an approved equivalent test method shall be performed to determine that all welded and brazed joints are liquid tight. A light test shall be performed by passing a lamp having a power rating of not less than 100 watts through the entire section of the ductwork to be tested. The lamp shall be open so as to emit light equally in all directions perpendicular to the duct walls. A test shall be performed for the entire duct system, including the hood-to-duct connection. The Contractor, Owner, Architect, Engineer, Test and Balance Contractor and the Equipment Manufacturer shall all be present during the Code Official Inspection(s).
  - B. Prior to the Code Official Inspection(s), the Contractor and the Equipment Manufacturer shall perform a pre-test on all duct systems to include a flashlight test of the ductwork. Any deficiencies shall be corrected and re-tested prior to the formal inspection(s) by the Code Official.
- 3.11 HOOD PERFORMANCE TESTING:
- A. Performance test(s) shall be conducted by the Contractor and witnessed by the Code Official upon completion and before final approval of the installation of the ventilation system serving the commercial kitchen appliances. The test(s) shall verify the rate of exhaust airflow and makeup airflow as required as well as the proper operation of the system. The Contractor shall be responsible to provide the necessary equipment and perform the test including 45 second white smoke candles. The test(s) shall emulate actual cooking conditions with all appliances in operation. The test(s) shall also include validation of the automatic controls systems. The

Contractor, Owner, Architect, Engineer, Test and Balance Contractor and the Equipment Manufacturer shall all be present during the Code Official Inspection(s).

- B. Prior to the Code Official Inspection(s), the Contractor and the Equipment Manufacturer shall perform pre-test(s) on all hood systems to include smoke bomb testing with 45 second white smoke candles. The pre-test(s) shall emulate actual cooking conditions with all appliances in operation. The test(s) shall also include validation of the automatic controls systems. Any deficiencies shall be corrected and re-tested prior to the formal inspection(s) by the Code Official.

END OF SECTION 233800

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## SECTION 237433 - DEDICATED OUTDOOR-AIR UNITS

### PART 1 – GENERAL:

#### 1.1 RELATED DOCUMENTS

- A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.
- B. Each Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.
- C. Each Contractor's attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.
- D. Each Contractor's attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine, VFDs to be furnished by the contractor.
- E. Each Contractor's attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

#### 1.2 SCOPE

- A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.
- B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
- C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.
- D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 – PRODUCTS:

- 2.1 ACCEPTABLE MANUFACTURERS: AAON, JCI/York, McQuay, Trane.
- 2.2 Provide factory built and factory tested air handling units of sizes, capacities and configurations as scheduled and as specified herein. Unit layout shall be dual path, providing one path for outside air with all components arranged in series as specified and providing one path for exhaust air with all components arranged in series as specified.
- 2.3 Provide factory installed external support kit on the base of the unit. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned, coated with rust-inhibiting primer and finished with rust inhibiting enamel.
- 2.4 CASINGS:
- A. Unit shall be double wall foam injected constructed in all sections. Foil facing on insulation shall not be acceptable as a substitute for double wall construction. Insulate all sections with 2" thick foam injected insulation, 1 ½ lb per cubic foot density. All panels shall be solid on the interior and exterior. Insulation shall comply with NFPA 90A. Fiberglass insulation shall not be acceptable.
  - B. Unit shall be constructed of a complete structural frame with removable panels. Removal of all exterior panels shall not affect the structural integrity of the unit. Installing Contractor shall be responsible to provide connection flanges and all other framework that is needed on unit to ensure that removals of unit's panels shall not affect structural integrity.
  - C. All exterior panels and structural frames shall be constructed of G90-U galvanized steel. Casings not constructed of G90-U galvanized steel, casings with welds on interior and exterior surfaces that have burned through to exterior surfaces shall be chemically cleaned, coated with rust inhibiting primer and finished with rust inhibiting enamel.
  - D. Construct casing sections located upstream of the supply fan for operation at 4 inches water gauge negative static pressure and casing sections located downstream of the supply fan for operation at 6 inches water gauge positive static pressure.
  - E. All joints between exterior panels and structural frames shall have seals and gaskets with closed-cell foam gasketing for air seal and acoustical break.
  - F. As required for routine service access, unit shall be supplied with full height, galvanized, double wall, hinged, removable access doors. Access door shall have a full perimeter automotive type gasket to prevent air leakage, and Ventlock style handle that can be opened from unit interior. Doors shall open against system pressure. If access doors open against unit operating pressure, provide safety latches that allow access doors to partially open after the first handle movement and fully open after second handle movement. All handles shall operate easily without special tools.

## 2.5 FAN SECTIONS:

- A. Provide fan sections with fan type as specified on drawings designed and suitable for class or service indicated. Fan sections shall have full height, double wall hinged, removable access doors on drive side for inspection and maintenance of internal components. Fan sections with plug fans shall have galvanized expanded metal access door guards to prevent unauthorized entry into fan sections when access doors are opened.
- B. Provide belt driven fans with adjustable pitch pulley permitting fan speed to be varied. Select pulley for mid-point of adjustable range. Design fan shafts so as not to pass through first critical speed when unit comes up to rated RPM. Statically and dynamically balance fan assemblies in fan housing after final assembly. Belts shall be enclosed as required by OSHA standard 29 CFR 1910 to protect worker from accidental contact with belts and sheaves. Provide multi-sheave/belt/pulley arrangements for fans with motor horsepower 5 hp and greater.
- C. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with a minimum of 2-inch spring isolators. Provide adjustable motor base, adjusted with mounting bolts, to provide variation in center distance. Provide locking nuts, or similar devices, to secure base in proper position. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A. Fan and motor assembly shall be weighed at the manufacturer's factory for isolator selection. Vibration shall be measured at each fan shaft bearing in horizontal, vertical and axial directions. All fans shall have pillow block bearings with minimum L-50 200,000 hour rating. Provide grease lubricated fan bearings with externally accessible fittings for lubrication. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.
- D. Motors shall be 3 phase ODP with NEMA frame and 1.15 service factor. Motor base shall be adjustable. Motor brake horsepower shall not exceed scheduled values. Fan brake horsepower shall not exceed 85% of motor horsepower. All motors shall comply with EPACT efficiency requirements. Refer to Specification Section – ELECTRIC MOTORS, ETC. for more requirements. Fan sections controlled by variable frequency drives and shall be factory installed. Refer to Specification Section - CONTROLS for all VFD specification requirements.

## 2.6 COIL SECTIONS AND DRAIN PANS:

- A. Provide double wall casing for coil sections. Inside surfaces exposed to the air stream shall be constructed of stainless steel. Design internal structure of coil section to allow for removal of coils. Provide suitable baffles to assure no air bypass around coils. Condensate drain pans and coil casing and all fasteners shall be constructed of stainless steel. Insulate coil section casings and drain pans as prior specified.
- B. All coils shall be tested at 200 psig air pressure while submerged in water. Coil performance shall be certified in accordance with ARI Standard 410. All coils shall have stainless steel casings. Construct coil headers of round copper pipe or cast iron. Clearly label supply and return headers on the outside of the units such that the direction of coil water flow is counter to the direction of air flow. If two or more coils are stacked in the unit, install intermediate drain pan channels between the coils to drain condensate to main drain pans without flooding lower coils or passing condensate through the air stream.

- C. Provide type 304 sealed stainless steel drain pans. Encase insulation between exterior and interior walls. Drain pans shall be sloped in two planes; cross break interior pans and pitch toward drain connections to ensure complete condensate drainage. Drain pans shall be installed under the complete cooling coil section. All drain pan connections will be to the side of the unit to ensure proper trapping. Units without 2-way sloped drain pans shall coat drain pans with anti-microbial treatment.
  - D. A 20 gauge, reinforced sheetmetal baffle shall be field or factory provided across the top of the entire coil protected with a freeze-stat. Baffle shall be full width of unit and 24" minimum in length. The purpose of the baffle is to prevent nuisance freeze-stat trips from cold air passing over the top of the coil near the freeze-stat.
- 2.7 DAMPERS: Provide internally mounted ultra low leak outside air dampers as specified on drawings. Dampers shall be double-skin airfoil design. Construct damper blades and damper frames of galvanized steel. Blades shall rotate on stainless steel sleeve bearings. Leakage rate shall not exceed 5 CFM/square foot at one inch water gauge and 9 CFM/square foot at 4 inches water gauge.
- 2.8 ENERGY RECOVERY SECTION: Manufacturers: Thyvent, Fresh Air Solutions, Semco, Novell-aire, XETEX. Energy Recovery Modules shall be installed in casing structure to match the OA unit construction throughout. A removable panel shall be provided to access the energy recovery cassette for service and inspection. Energy recovery wheel shall be mounted in a slide out cassette. A wiring box shall be provided for permanent connection of a power source. The Energy Recovery Cassette shall contain a 4 Angstrom total energy recovery wheel for sensible and latent energy recovery. A wheel drive motor having permanently sealed ball bearings shall be provided with plug-in connection to a receptacle mounted within the cabinet. Provide the ERW with a factory installed starter/disconnect. The total enthalpy wheel shall be supplied by the module manufacturer and be constructed of a light weight polymer material with a permanently bonded silica gel desiccant coating. Eight energy transfer sections shall be removable from the energy recovery wheel without the use of special tools. The units shall not require a condensation pan. Energy transfer ratings must be ARI Certified to Standard 1060 and bear the ARI certification symbol for ARI Air-to-Air Energy Recovery Ventilation Equipment Certification Program based on ARI 1060.
- 2.9 FILTERS: Filters shall be 2" thick, 30% efficient Merv 8, pleated and disposable. The filter pressure drop shall be 0.28" at 500 fpm face velocity. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2. Provide filter boxes with either hinged access doors at each end. Provide racks to receive filters in either flat or angle type pattern. Provide air filters to fit in filter box of the type scheduled on the drawings. Sizes and quantities shall be per the manufacturer's recommendations. Refer to Specification Section COMMON WORK RESULTS FOR HVAC for Temporary Use of Equipment Requirements and filter quantities.
- A. Disposable Filter Media: Filter Media shall be 2" thick fiberglass Air Filter Media Pads with an initial maximum pressure drop of 0.20"wg @ 500 fpm.
  - B. Retainer Frame and Backing Wire Frame: Provide for each filter to support the disposable filter media. Products shall be factory assembled. Retainer Frame shall be 10 gauge minimum and shall be provided with additional angled support prongs to prevent sagging filter pad. Frame shall

be 18 gauge minimum and shall have flush mitered corners. Frames shall also be provided with 16 gauge galvanized 1x1 welded wire support backing.

PART 3 – EXECUTION:

- 3.1 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.
- 3.2 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.
- 3.3 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.
- 3.4 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.
- 3.5 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly and O&M staff shall be able to operate the system prior to turnover.
- 3.6 Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.
- 3.7 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative.

END OF SECTION 237433

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## SECTION 238146 - WATER-SOURCE UNITARY HEAT PUMPS

### PART 1 - GENERAL:

- 1.1 ACCEPTABLE MANUFACTURERS: Water Furnace, Climate Master, FHP, Carrier, AAON.
- 1.2 A 100% complete mockup installation shall be required for a typical unit. This mockup shall be inspected/reviewed by the Engineer prior to installation of other units.
- 1.3 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.
- 1.4 Equipment shall be specifically designed for applications within conditioned interior areas. Capacities shall be rated in accordance with ARI for geothermal applications. Equipment shall be ETL or CSA approved. All equipment shall have decals and labels to aid in servicing and indicate caution areas.
- 1.5 Equipment shall be completely factory assembled and tested, piped, internally wired and fully charged with Refrigerant R-410A. Threaded female water inlet and outlet connections, threaded female condensate connection, duct collars and all safety controls shall be furnished and factory installed.
- 1.6 A terminal block with screw terminals shall be provided for control wiring. A condensate overflow device shall be factory installed to stop compressor operation if drain pan overflow is imminent. An energy management relay to allow unit control by an external source shall be factory installed.
- 1.7 Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for special warranty requirements.

### PART 2 – PRODUCTS

- 2.1 CASING AND CABINET: The cabinet shall be constructed of galvanized steel and factory painted with ½” fiberglass on interior, discharge duct collar and return collar. Lift-out removable access panels shall be provided for access to the compressor and blower assembly compartments.
- 2.2 DRAIN PAN: The drain pan shall be constructed of stainless steel and insulated to prevent sweating. The bottom of the drain pan shall be sloped on two planes which will direct the condensate to the drain connection. When the unit is installed per the manufacturer’s instructions, the drain pan shall be tested as follows: (1) Temporarily plug the drain pan, (2) fill the

- drain pan with 2" of water or the maximum allowed by the drain pan depth, whichever is smaller, (3) remove the temporary plug and verify the drain pan removes the water within 3 minutes.
- 2.3 COMPRESSOR: The compressor or compressors shall be high-efficiency, hermetically sealed scroll type with internal vibration isolation. Compressors motors shall be equipped with overload protection. Refer to the drawing schedules as multiple compressor types shall be utilized.
- 2.4 AIR-TO-REFRIGERANT HEAT EXCHANGER: The air-to-refrigerant heat exchanger shall be constructed of staggered copper tubes with die formed corrugated aluminum fins mechanically bonded to the tubes. The air-to-refrigerant heat exchanger shall have a working pressure rating of 400 PSIG. Multiple compressor equipment shall provide a single air-to-refrigerant heat exchanger for each compressor.
- 2.5 WATER-TO-REFRIGERANT HEAT EXCHANGER: The water-to-refrigerant heat exchanger shall be of a high quality co-axial coil for maximum heat transfer and insulated to prevent condensation at low temperatures. The copper coil shall be fluted to enhance heat transfer and minimize fouling and scaling. The coil shall have a working pressure of 600 psig on the refrigerant side and 400 psig on the water side.
- 2.6 REVERSING VALVE: The reversing valve shall be a pilot operated sliding piston type with replaceable encapsulated magnetic coil. The reversing valve shall be energized in the cooling cycle.
- 2.7 REFRIGERANT TUBING: Refrigerant tubing shall be constructed of copper. All low temperature refrigerant lines shall be insulated with an elastomeric insulation that has a 3/8" thick wall, flame spread rating of less than 25 and smoke density rating of less than 50, as tested in accordance with ASTM-84. The elastomeric insulation shall have a UL 94V-5 rating.
- 2.8 REFRIGERANT METERING: The equipment shall be provided with a thermal expansion valve. This device shall allow operation of the equipment in the range of 25 to 110° F entering fluid temperatures and 40 to 95° F entering air temperatures. The equipment shall only operate with one variable (enter water temperature, entering air temperature, cfm or gpm) at an extreme condition. All other variables must be within the nominal range of operation.
- 2.9 REFRIGERANT SYSTEM SERVICE ACCESS: The equipment shall be provided with factory supplied high and low pressure Schrader ports for easy refrigerant pressure or temperature testing.
- 2.10 BLOWER AND MOTOR ASSEMBLY: See Schedules for motor type. The motor shall have permanently lubricated and sealed bearings. All motors shall have internal thermal overload protection. The fan assembly shall be arranged for back, left, or right discharge. The discharge must also be capable of being changed in the field. Removal of the motor and fan wheel shall be made with the assistance of a factory provided orifice ring assembly. This assembly shall attach the wheel and motor to the fan housing providing single service access. Where available, provide one hand-held motor programming module to the Owner to utilize for startup and test and balance.



- 2.11 UNIT CONTROLS – SAFETIES: A factory tested and installed control box shall contain all necessary devices to allow heating and cooling operation of the equipment to occur. These devices shall be as follows (1) 24 Vac, energy limiting class II transformer. (2) Blower motor controller shall be a 24 Vac relay. (3) Compressor controller shall be a 24 Vac contactor. All three-phase operated equipment shall have a contactor that interrupts all three-phases providing power to the compressor. (4) Electrically operated safety lockout relay. This device shall prevent operation and anti-short cycling of the compressor during adverse conditions of operation. This device may be reset by either a remote thermostat or momentary interruption of power. (5) High pressure switch shall protect the compressor against operation at refrigerant system pressures in excess of 395 PSIG. (6) Low pressure switch shall prevent compressor operation underneath low charge or catastrophic loss of charge situations.
- 2.12 AIR FILTER SYSTEM: The Contractor shall completely assemble an Air Filter System for each unit and install ready to use. Heat pumps 5 tons and smaller require one 24" X 24" air filter system (one 24 X 24 filter). Heat pumps 6 tons through 10 tons require one 48" X 24" air filter system (two 24 X 24 filters). Heat pumps larger than 10 tons require one 72" x 48" air filter system (Six 24 X 24 filters). See plans for sizes and quantities. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for Temporary Use of Equipment Requirements and filter quantities.
- 2.12.1 Side Access Filter Housing: Housings shall accommodate required quantity of 24" X 24" X 2" deep flat filters as noted above. Housings shall be factory assembled, have one hinged access door with quick access latches (operable without special tools), and be constructed on 16 gauge aluminized steel minimum.
- 2.12.2 Filters shall be 30% efficient Merv 8, pleated and disposable. Provide Flanders/FFI Pre Pleat 40, 24" x 24" x 2" thick or approved equal. The filter pressure drop shall be 0.28" at 500 fpm face velocity. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2.
- 2.13 HOSE KIT & PIPING PACKAGE: Hose kits and piping package shall be as scheduled on the drawings. Single piece hose kits shall be provided for hose kits that are 1-1/2" or less in size. Two piece hose kits shall be provided for hose kits that are 2" and larger in size. Hose kits shall be the pipe runout size, not heat pump connection sizes. No exceptions!
- 2.13.1 Provide a factory-assembled hose kit/piping package for supply and return connections for each heat pump. Kits may be mounted in any direction and shall not require straight sections of pipe either upstream or downstream for proper operation. All hoses shall be equipped with end connections at terminal unit and shall be 24" long. All end connections shall be either permanently crimped swivel ends or butt welded to carbon steel end fittings to meet stated pressure ratings. Operational temperature shall be rated from fluid freezing to 200 degrees F. Minimum burst pressure shall be four times the working pressure. Furnish with field flushing connection fitting. Up to 1-1/4" shall be reinforced, fire retardant EPDM rubber, bonded to the inside wall of braiding. 1 1/2" and larger shall be a corrugated type 321 stainless steel tube.
- 2.13.2 Each supply side (water inlet) hose kit/piping package shall include a single piece Y - valve body for sizes up to 1-1/2" and shall be constructed of hot forged brass with threaded inlets and outlets. 2" and larger sizes shall be two-piece and constructed of ductile iron with

threaded inlets and outlets. All valve bodies are suitable for a minimum of 400 PSIG working pressure. Include single pressure/temperature test ports for verifying the pressure differential and system temperature. Include full flow design ball valve with blow out stems for shut off. Strainer shall be Y-type configuration furnished with hose connector blow down valve. Strainer screen shall be stainless steel mesh and easily accessible for cleaning without disconnecting hoses. All valves shall be labeled with flow direction, manufacturer and model number, unit tagging.

- 2.13.3 Each return side (water outlet) hose kit/piping package shall include a single piece Y - valve body for sizes up to 1-1/2" and shall be constructed of hot forged brass with threaded inlets and outlets. 2" and larger sizes shall be two-piece and constructed of ductile iron with threaded inlets and outlets. All valve bodies are suitable for a minimum of 400 PSIG working pressure. Include single pressure/temperature test ports for verifying the pressure differential and system temperature. Include full flow design ball valve with blow out proof stems for shut off. All valves shall be labeled with flow direction, manufacturer and model number, unit tagging. Include automatic flow control valves which shall be factory set to rated flow and shall automatically control the flow to within 10% of the rated value subject to the operating parameters of 2-80 psid, fluid freezing to 225°F, 2-7 fps. Also provide a three-wire, two-way, two-position control valve with actuator. Actuator shall be field installed by the TCC.
- 2.14 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section GENERAL PROVISIONS - MECHANICAL. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements.
- 2.15 All training to occur after building completion. System shall function properly and O&M staff shall be able to operate the system prior to turnover.

END OF SECTION 238146

## SECTION 238241 - WATER-TO-WATER HEAT PUMP

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes unitary heat pumps with refrigerant-to-water heat exchangers, refrigeration circuits, and refrigerant compressor(s).

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each water-source unitary heat pump.
  - 2. Include rated capacities, operating characteristics, furnished specialties, and accessories.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of water-source unitary heat pump, signed by product manufacturer.
- B. Field quality-control reports.
- C. Sample Warranty: For manufacturer's warranty.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water-source unitary heat pumps to include in emergency, operation, and maintenance manuals.

#### 1.6 MAINTENANCE MATERIAL SUBMITTALS

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

#### 1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of water-source unitary heat pumps that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, refrigeration components.
  - 2. Warranty Period: Five years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 Operating Conditions

- A. Provide water-to-water heat pump with the capacity as scheduled on drawings at job site elevation listed in Section 15050.
- B. Heat Pump shall be designed to operate using R-454b Refrigerant.
- C. Heat Pump shall be designed for parallel evaporator water flow.
- D. The liquid to be heated and cooled will be water containing corrosion inhibitors.
- E. Heat Pump shall be designed to operate using 480volt, 3 phase, 60 (50) Hz electrical power supply.

### 2.2 Water-to-Water Packaged Heat Pump

- A. Approved manufacturers: Multistack, Climacool, Arcti-Chill, Mammoth, Waterfurnace.
- B. System Description: Heat Pump shall incorporate Scroll-type compressors and can consist of multiple ton modules. Each refrigerant circuit shall consist of an individual compressor, common dual circuited condenser, dual circuited evaporator, thermal expansion valves, reversing valve, and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-circuit heat pump must be able to produce chilled water even in the event of a failure of one or more refrigerant circuits.
- C. General
  - 1. Heat Pump Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236.
  - 2. Modules shall ship wired and charged with refrigerant. All modules shall be factory run tested prior to shipment on an AHRI certified or 3<sup>rd</sup> party verified test stand.
  - 3. Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module.
- D. Each module shall be supplied with a light weight aluminum frame with sound reduction panels. Panels are powder coated 20 gauge steel with 1" of fiberglass insulation to reduce sound levels. Optional sound package will reduce sound pressure levels measured at 1 meter at a minimum of 12 dBA.
- E. Water Mains: Each module shall include supply and return mains for both load and source-sink water. Cut grooved end connections are provided for interconnection to six inch standard (6.625" outside diameter) piping with grooved type couplings. Rolled grooved shall be unacceptable. Water Mains shall be installed such that they are beneath any power or control wiring so as to insure for safe operation in the event of condensation or minor piping leaks.
- F. Heat Exchangers: Each load and source-sink heat exchanger shall be brazed plate heat exchangers constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig refrigerant side working pressure and 360 psig water side working pressure. Heat exchangers shall be mounted below the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up.

- G. Compressor: Each module shall contain two hermetic scroll compressors independently circuited and with internal spring isolation mounted to the module with rubber-in-shear isolators. Each system also includes high discharge pressure and low suction pressure manual reset safety cut-outs.
- H. Central Control System.
1. Scheduling of the various compressors shall be performed by a microprocessor based control system (Master Controller). A new lead compressor is selected every 24 hours to assure even distribution of compressor run time. The Master Controller shall monitor and report the following on each refrigeration system:
    2. Discharge Pressure Fault
      1.
        - a. Suction Pressure Fault
        - b. Compressor Winding Temperature
        - c. Suction Temperature
        - d. Load Leaving Water Temp.
        - e. Source-Sink Leaving Water Temp.
    3. The Master Controller shall be powered by the chillers single point power connection and shall monitor and report the following system parameters:
      - a. Load Water Entering and Leaving Temperature
      - b. Source-Sink Water Entering and Leaving Temperature
      - c. Load Water and Source-Sink Water Flow
    4. An out of tolerance indication from these controls or sensors shall cause a "fault" indication at the Master Controller and shutdown of that compressor with the transfer of load requirements to the next available compressor. In the case of a System Fault the entire heat pump will be shut down. When a fault occurs, the Master Controller shall record conditions at the time of the fault and store the data for recall. This information shall be capable of being recalled through the keypad of the Master Controller and displayed on the Master Controller's 2 line by 40 character back-lit LCD. A history of faults shall be maintained including date and time of day of each fault (up to the last 20 occurrences).
    5. Individual monitoring of leaving water temperatures from each refrigeration system shall be programmed to protect against heat exchanger freeze-up.
    6. The control system shall monitor entering and leaving water temperatures to determine system load and select the number of compressor circuits required to operate. Response times and set points shall be adjustable. The system shall provide for variable time between compressor sequencing and temperature sensing, so as to optimize the heat pump performance to different existing building loads.
    7. The heat pump mode (heating or cooling) shall be selected by an external dry contact interlock to the Master Controller. If no interlock is present or in the event of a reversing valve solenoid failure, the system shall revert to heating mode.
  - I. Heat pump shall have a single point power connection and external inputs and outputs to be compatible with the building management system. Inputs/Outputs include:
    1. Remote Start/Stop
    2. Cooling Alarm
  - J. Each inlet water header shall incorporate a built in 30-mesh (maximum) in-line strainer system to prevent heat exchanger fouling and accommodate 100% flow filtration with a minimum surface area of 475 sq inches per module.
  - K. Single Point Power: Chiller shall be equipped with a pre-engineered genuine buss bar electrical system for single point power rated at a 5,000 amp SCCR. Where the equipment size exceeds the amp rating of the buss bar, multiple power connections may be applied. Pre-engineered system shall also incorporate individual module isolation circuit breakers for full redundancy and ability of a module to be taken off-line for repair while the rest of the modules continue to operate. Individual power feeds to each module shall be unacceptable.

- L. Head Pressure Control Valves: Heat exchangers on the source/sink side of the Heat Pump Modules shall be equipped with fully modulating motorized butterfly type valves driven by a signal from the master controller and used to maintain head pressure whenever necessary.
- M. Butterfly type isolation valves shall incorporate appropriate accessories and controls to allow the chiller to operate efficiently in a variable primary flow system and will modulate for leaving water temp control to the load.
- N. Variable flow valves are selectable via the chiller master controller as a chiller no load bypass.
- O. Load and Source heat exchangers shall be equipped with motorized modulating butterfly type valves driven independently by signals from the module controller and powered from the main power feed. The motorized actuators shall be modulating NEMA 2, IP-54 with a stroke time of no more than 35 seconds. NEMA 4X rated valves with easily visible position indicators and internal thermal motor overload protection. Valves shall be fast acting type with a maximum stroke time (full closed to full open) of 15 seconds.
- P. Isolation valves shall be installed between the heat exchangers and water supply mains for heat exchanger isolation and removal without the requirement to remove a module or shut down the entire chiller allowing for total access to all serviceable components.

## 2.3 SAFETIES, CONTROLS AND OPERATION

- A. Heat pump safety controls system shall be provided with the unit (minimum) as follows:
  - 1. Low refrigerant pressure
  - 2. Loss of flow through the source/sink heat exchanger
  - 3. Loss of flow through the load heat exchanger
  - 4. High refrigerant pressure
  - 5. High compressor motor temperature
  - 6. Low suction gas temperature
  - 7. Low leaving water temperature
- B. Failure of heat pump to start or heat pump shutdown due to any of the above safety cutouts shall be annunciated by display of the appropriate diagnostic description at the unit control panel. This annunciation will be in plain English. Alphanumeric codes shall be unacceptable.
- C. The heat pump shall be furnished with a Master Controller as an integral portion of the heat pump control circuitry to provide the following functions:
  - 1. Provide automatic heat pump shutdown during periods when the load level decreases below the normal operating requirements of the heat pump. Upon an increase in load, the heat pump shall automatically restart.
  - 2. Provisions for connection to automatically enable the heat pump from a remote energy management system.
  - 3. The control panel shall provide alphanumeric display showing all system parameters in the English language with numeric data in English units.
- D. Normal Heat pump Operation
  - 1. When heat pump is enabled, the factory supplied MasterController modulates the heat pump capacity from minimum to maximum as required by building load.
  - 2. The heat pump control system shall respond to Entering Water Temperature and will have an integral reset based on entering water temperature to provide for efficient operation at part-load conditions.
  - 3. The operating mode (heating or cooling) shall be determined by a customer provided dry contact interlock.

- E. Power Phase Monitor
  - 1. Provide a Power Phase Monitor on the incoming power supply to the heat pump. This device shall prevent the heat pump from operating during periods when the incoming power is unsuitable for proper operation. The Power Phase Monitor shall provide protection against the following conditions:
    - a. Low Voltage (Brown-Out)
    - b. Phase Rotation
    - c. Loss of Phase
    - d. Phase Imbalance

### PART 3 - INSTALLATION

#### 3.1 PIPING SYSTEM FLUSHING PROCEDURE

- A. Prior to connecting the heat pump to the condenser and chilled water loop, the piping loops shall be flushed with a detergent and hot water (110-130° F) mixture to remove previously accumulated dirt and other organics. In old piping systems with heavy encrustation of inorganic materials consult a water treatment specialist for proper passivation and/or removal of these contaminants.
- B. During the flushing, a 30 mesh (max.) Y-strainers (or acceptable equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The use of on board chiller strainers shall not be acceptable. The flushing process shall take no less than 6 hours or until the strainers when examined after each flushing are clean. Old systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer's instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.
- C. Prior to supplying water to the heat pump the Water Treatment Specification shall be consulted for requirements regarding the water quality during heat pump operation. The appropriate heat pump manufacturer's service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.

#### 3.2 Water Treatment Requirements

- A. Supply water for both the chilled water and condenser water circuits shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the heat pump's heat exchangers, headers and associated piping. Cycles of concentration shall be controlled such that recirculated water quality for modular heat pumps using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:

|                                  |                                |
|----------------------------------|--------------------------------|
| pH                               | Greater than 7 and less than 9 |
| Total Dissolved Solids (TDS)     | Less than 1000 ppm             |
| Hardness as CaCO <sub>3</sub>    | 30 to 500 ppm                  |
| Alkalinity as Ca CO <sub>3</sub> | 30 to 500 ppm                  |
| Chlorides                        | Less than 200 ppm              |
| Sulfates                         | Less than 200 ppm              |

3.3 Warranty and Start-Up

- A. Manufacturer's Warranty: Manufacturer shall provide full parts-only warranty coverage for entire chiller for a period of one year. All parts shall be warranted against defects in material and workmanship. Similar parts-only coverage shall be provided for the chillers compressors for a period of five years. The warranty period shall commence either on the equipment start-up date or six months after shipment, whichever is earlier.
- B. Manufacturer shall provide the services of a Factory Authorized Service Engineer to provide complete start-up supervision. Factory Authorized Service Engineer shall also be responsible for assembly of the chillers cabinetry package and electrical bus bar system.
- C. Refer to COMMON WORK RESULTS FOR HVAC for training requirements.

END OF SECTION 238241



## SECTION 260010 - GENERAL REQUIREMENTS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Instructions to Bidders, General and Special Conditions, and all other contract documents shall apply to the Contractor's work as well as to each Sub Contractor's work. Each Contractor is directed to familiarize themselves in detail with all documents pertinent to this Contract. In case of conflict between these General Provisions and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination.
- C. Each Contractor shall be governed by any alternates, unit prices and Addenda or other contract documents insofar as they may affect their part of the work.

#### 1.2 SUMMARY

- A. Section Includes general requirements applicable to work specified in Divisions 26, 27, and 28.
- B. The work included in this division consists of the furnishing of all labor, equipment, transportation, supplies, material, and appurtenances and performing all operations necessary for the satisfactory installation of complete and operating Electrical Systems indicated on the drawings and/or specified herein.
- C. Any materials, labor, equipment, or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Electrical Systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the drawings and specifications, shall be included as part of this Contract. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in their bid, and that they will be responsible for the approved satisfactory functioning of the entire system without extra compensations.
- D. It is not the intent of this section of the specifications (or the remainder of the contract documents) to make any specific Contractor, other than the Contractor holding the prime contract, responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be done through the Contractor to the Architect (if applicable), then to the Engineer.
- E. This section of the Specifications or the arrangement of the contract documents shall not be construed as an attempt to arbitrarily assign responsibility for work, material, equipment or services to a particular trade Contractor or Sub-Contractor. Unless stated otherwise, the

subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

- F. Any reference within these specifications to a specific entity, i.e., "Electrical Contractor" is not to be construed as an provide to limit or define the scope of work for that entity or assign work to a specific trade or contracting entity. Such assignments of responsibility are the responsibility of the Contractor holding the prime contract, unless otherwise provided herein.
- G. In each of the specifications and drawings referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears.
- H. Intent and Interpretation
  - 1. It is the intent of these specifications and all associated drawings that the Contractor provide finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete, tested and ready for operation."
  - 2. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.
  - 3. It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc. as necessary for trouble free operation; tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.
  - 4. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
  - 5. The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer/ Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops, the interpretation of the Engineer shall be final.
  - 6. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.
- I. Drawings and Specifications
  - 1. The drawings are diagrammatic only and indicate the general arrangement of the systems and are to be followed insofar as possible. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted in writing to the Engineer for approval before proceeding with the work. The Contract

Drawings are not intended to show every vertical or horizontal offset which may be necessary to complete the systems. Contractors shall, however, anticipate that additional offsets may be required and submit their bid accordingly.

2. The drawings and specifications are intended to supplement each other. No Contractor, bidder, proposer, or supplier shall take advantage of conflict between them, or between parts of either, but should this condition exist, the Contractor or supplier shall request a clarification of the condition at least ten days prior to the submission of bids so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be the determining factor. In all instances, unless modified in writing and agreed upon by all parties thereto, the Contract to accomplish the work shall be binding on the affected Contractor.
3. The drawings and specifications shall be considered to be cooperative and complimentary and anything appearing in the specifications which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
4. This Contractor shall make all their own measurements in the field and shall be responsible for correct fitting. They shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.
5. The Engineer shall reserve the right to make minor adjustments in location of conduit, fixtures, outlets, switches, etc., where they consider such adjustments desirable in the interest of concealing work or presenting a better appearance.
6. Each Contractor shall evaluate ceiling heights called for on Architectural Plans and ensure that these heights may be maintained after all mechanical and electrical equipment is installed. Where the location of Electrical equipment may interfere with ceiling heights, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work on the part of the Contractor or unduly delay the work.
7. Should overlap of work between the various trades become evident, this shall be called to the attention of the Engineer. In such an event, neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.
8. The Electrical drawings are intended to show the approximate location of equipment, materials, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions whether given in figures or scaled shall be verified in the field. In case of conflict between small- and large-scale drawings, the larger scale drawings shall take precedence.
9. The Electrical Contractor and their Sub-Contractors shall review all drawings in detail as they may relate to his work (structural, architectural, site survey, mechanical, etc.). Review all drawings for general coordination of work, responsibilities, ceiling clearances, wall penetration points, chase access, fixture elevations, etc. Make any pertinent coordination or apparent conflict comments to the Engineers at least ten days prior to bids, for issuance of clarification by written addendum.
10. Where on any of the drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornament or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

### 1.3 COST BREAKDOWN AND PAY APPLICATIONS

- A. Within thirty days after acceptance of the Contract, each Contractor is required to furnish to the Engineer one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made on forms provided or approved by the Engineer or Architect. Payments will not be made until satisfactory cost breakdowns are submitted. Refer to Division 00 and 01 specification sections for additional requirements.
- B. In addition to cost breakdowns by specification section, the following shall also be provided: Material and labor shall be listed separately. These items are in addition to items listed in Division 01 specifications. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc. The breakdown shall be minimally as follows:
1. Permitting
  2. Mobilization
  3. Electrical Submittals
  4. Electrical Coordination Drawings
  5. Temporary Power
  6. Interior Lighting Materials & Labor
  7. Exterior Lighting Materials & Labor
  8. Lighting Controls Materials & Labor
  9. Lighting and Lighting Controls Startup, Testing, & Verification (equal to 2.5% of Equipment Value)
  10. Electrical Distribution Equipment Materials & Labor
  11. Electrical Distribution Equipment Startup, Testing, & Verification (equal to 2.5% of Equipment Value)
  12. Electrical Distribution Equipment Power System Study & Field Adjusting
  13. Feeders Materials & Labor
  14. Branch Circuiting Materials & Labor
  15. Service Grounding Materials & Labor
  16. Surge Suppression Materials & Labor
  17. Electrical Devices Materials & Labor
  18. Cable Trays Materials & Labor
  19. Underground Duct Banks Materials & Labor
  20. Fire Alarm Materials & Labor
  21. Fire Alarm System Startup, Testing, & Verification (equal to 5% of Equipment Value)
  22. Owner Training
  23. Punchlist
  24. As-Built/Record Drawings
  25. O&M Manuals
  26. Warranty
  27. Demobilization

### 1.4 REFERENCES

- A. Abbreviations and Acronyms
1. A, AMP: Ampere
  2. ADA: Americans with Disabilities Act.

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3. AFF: Above Finished Floor
  4. AFG: Above Finished Grade
  5. AHJ: Authority Having Jurisdiction
  6. AHU: Air Handling Unit
  7. AIC: Amps Interrupting Capacity
  8. ANSI: American National Standards Institute.
  9. ASA: American Standards Association.
  10. ASTM: American Society for Testing Materials.
  11. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers.
  12. ATS: Automatic Transfer Switch
  13. A/V: Audio/Visual
  14. AWG: American Wire Gauge
  15. BAS: Building Automation System
  16. BFG: Below Finished Grade
  17. BICSI: Building Industry Consulting Services International
  18. C: Conduit
  19. CB: Circuit Breaker
  20. CFCI: Contractor Furnished, Contractor Installed
  21. CFOI: Contractor Furnished, Owner Installed
  22. CKT: Circuit
  23. CLG: Ceiling
  24. CT: Current Transformer
  25. CM: Construction Manager
  26. DDC: Direct Digital Building Controls
  27. DOAS: Dedicated Outdoor Air System
  28. DWG: Drawing
  29. EC: Electrical Contractor
  30. ELEV: Elevator
  31. EM: Emergency
  32. EPO: Emergency Power Off
  33. FA: Fire Alarm
  34. FAA: Fire Alarm Annunciator
  35. FACP: Fire Alarm Control Panel
  36. FCC: United States Federal Communications Commission
  37. FFE: Finished Floor Elevation
  38. FLA: Full Load Amps
  39. G, GND: Ground
  40. GFCI: Ground Fault Circuit Interrupter
  41. GC: General Contractor
  42. HOA: Hands Off Auto
  43. HP: Horsepower
  44. IDF: Intermediate Distribution Frame
  45. IECC: International Energy Conservation Code
  46. ISO: International Standards Organization.
  47. IT: Information Technology
  48. KVA: Kilovolt-Amperes
  49. KW: Kilowatt
  50. KWH: Kilowatts Hours
  51. LRA: Locked Rotor Amps
  52. LTG: Lighting

- 53. MC: Mechanical Contractor
- 54. MCA: Minimum Circuit Ampacity
- 55. MCB: Main Circuit Breaker
- 56. MDF: Main Distribution Frame
- 57. MDP: Main Distribution Panel
- 58. MLO: Main Lugs Only
- 59. MOCP: Maximum Overcurrent Protection
- 60. MSB: Main Switchboard
- 61. N/A: Not Applicable
- 62. NEC: National Electrical Code
- 63. NECA: Standards for Installation.
- 64. NEMA: National Electrical Manufacturers Association.
- 65. NESC: National Electrical Safety Code.
- 66. NFPA: National Fire Protection Association.
- 67. NIC: Not in Contract
- 68. NRTL: Nationally Recognized Testing Laboratory
- 69. NTS: Not to Scale
- 70. N/A: Not Applicable
- 71. OFCI: Owner Furnished, Contractor Installed
- 72. OFOI: Owner Furnished, Owner Installed
- 73. OSHA: Office of Safety and Health Administration.
- 74. P: Pole, Poles
- 75. PC: Plumbing Contractor
- 76. PIR: Passive Infrared
- 77. RFI: Request for Information
- 78. RIO: Rough-in Only
- 79. RM: Room
- 80. SPD: Surge Protection Device
- 81. SS: Stainless Steel
- 82. SWBD: Switchboard
- 83. TIA: Telecommunications Industry Association
- 84. TYP: Typical
- 85. UL: Underwriters Laboratories, Inc.
- 86. UON or UNO: Unless otherwise noted.
- 87. UG: Underground
- 88. V: Volt, Volts
- 89. VFD: Variable Frequency Drive
- 90. W: Watts
- 91. WG: Wire Guard
- 92. WP: Weather Proof
- 93. XFMR: Transformer

B. Definitions

- 1. Architect: The Architect of Record for the project, if applicable.
- 2. Basis of Design (BOD): Documentation of primary thought processes and assumptions behind design decisions made to meet design intent. Describes systems, components, conditions, and methods chosen to meet intent.
- 3. Bidder/Proposer: Any person, agency or entity submitting a proposal to any person, agency, or entity for any part of the work required under this contract.

4. Contract Documents: All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Manager's Assignments, Architect's Supplemental Instructions, Construction Contract with Owner, etc.
  5. Contractor: Any Contractor whether bidding, proposing, or working independently or under the supervision of a General Contractor, Prime Contractor, or Construction Manager and who installs any type of Electrical Work as specified in the Contract Documents.
  6. Electrical Contractor: Any Contractor whether bidding or working independently or under the supervision of the entity holding the Prime Contract and who installs any type of Electrical work, such as: power, lighting, television, telecommunications, data, fiber optic, intercom, fire detection and alarm, security, video, underground or overhead electrical, etc.
  7. Electrical Sub-Contractor: Each or any Contractor contracted to, or employed by, the Electrical Contractor for any work required by the Electrical Contractor.
  8. Engineer: The Consulting Mechanical-Electrical Engineer consulting to the Owner, Architect, or Other, etc.
  9. Indicated: Listed in the Specifications, shown on the Plans or Addenda thereto.
  10. Install: Install equipment furnished by others in complete working order.
  11. Installer: Contractor or another entity engaged by Contractor as an employee, subcontractor, or sub-subcontractor, to perform a particular construction operation, including installation, erection, application, assembly, and similar operations.
  12. Furnish: Deliver to the site in good condition and turn over to the Contractor who is to install.
  13. Prime Contractor: The Contractor who has been engaged by the Owner in a contractual relationship to accomplish the work.
  14. Project: All of the work required under this Contract.
  15. Provide: Furnish and install complete, tested, and ready for operation.
  16. Start-Up: The activities where systems or equipment are initially tested and operated. Start-up is completed prior to functional testing.
  17. Typical: Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
  18. Vendor: Supplier of equipment.
- C. Reference Standards: Contractor is responsible for knowledge and application of current versions of all applicable standards and codes. Contractor shall adhere to the most recent revisions or version adopted by the Authorities Having Jurisdiction, including all relevant changes or addenda at the time of installation.
1. IEEE – Institute of Electrical and Electronics Engineers.
    - a. IEEE C2, National Electrical Safety Code
  2. NECA – National Electrical Contractors Association.
    - a. NECA 1, Standard for Good Workmanship in Electrical Construction
  3. NFPA - National Fire Protection Association.
    - a. NFPA 70, National Electrical Code (NEC)

4. OSHA - The Occupational Safety and Health Act

1.5 COORDINATION

A. Utility Company Requirements

1. Contact the utility company for specifics on construction of pads, conduit, etc., prior to bidding the work and determine all their requirements. All work shall be in accordance with their standards.
2. Each contractor, prior to bidding the work, is to contact the utility companies (electric and telecommunications) and determine the exact points of extension of all underground services in the field with a representative of each utility company. Also, obtain construction details on manholes, transformer pads, pedestal stub-ups, etc., from each utility company as applicable. Extension points indicated on the plans are approximate and are given for the bidder's information only.
3. The Contractor shall provide the local utility company with a drawing produced by a licensed Land Surveyor or a licensed Engineer and acceptable to the utility that locates the centerline of the service and connection point. Coordinate further requirements with utility company.
4. The Contractor is responsible for all fees, permit costs, etc., from the electrical utility, data, telephone, and cable TV companies. This includes any cost associated with the underground electrical service extension.

B. Coordination with Existing Utilities and Structures

1. The locations of all piping, conduits, cables, utilities, and manholes existing, or otherwise, that are present within the contract construction site, shall be subject to continuous uninterrupted maintenance with no exception unless the Owner of the utility grants permission for temporary interruption.
2. Known utilities and structures as available to the Engineer are shown on the drawings. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Contractor shall bear costs of repairing damaged utilities.
3. If utilities or structures are installed within the construction project boundary, the Contractor shall first probe and make every effort to locate the lines prior to excavating in the respective area.
4. Cutting into existing utilities and services shall be done in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.
5. The Contractor shall repair to the satisfaction of the Engineer any surface or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.
6. Machine excavation shall not be permitted within ten feet of existing gas or fuel lines. Hand excavate only in these areas, in accord with utility company, agency or other applicable laws, standards or regulations.
7. Protect all new or existing lines from damage by traffic, etc. during construction.
8. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.



- C. Interruption of Existing Services: In general, and to the extent possible, perform all work without interruption of the existing facilities' operations. Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions:
1. Notify the Owner, Architect, and Engineer no fewer than seven days in advance of proposed interruption of service.
  2. Provide the exact time the interruption will occur and the length of the interruption.
  3. Do not proceed with interruption of service without written permission from Owner, Architect, and Engineer.
  4. Failure to comply with this requirement may result in complete work stoppage by the Contractors involved until a complete schedule of interruptions can be developed.
  5. Contractor will not be entitled to additional compensation due to work stoppage mandated by unscheduled interruption.
  6. Coordinate interruptions with systems impacted by outages including but not limited to the following:
    - a. Generators
    - b. Emergency Lighting
    - c. Elevators
    - d. Fire Alarm Systems
  7. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore the service. The Contractor shall provide tools, materials, skilled journeymen of their own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation to the Owner, except where otherwise provided for in the contract for the work.
- D. Coordination Between Trades
1. The Contractor is expressly directed to read the General Conditions and all detailed sections of these specifications for all other trades and to study all drawings applicable to their work, including Architectural, Mechanical, Structural and other pertinent Drawings, to the end that complete coordination between trades will be affected.
  2. The Contractor is responsible for the correct location of all rough-in and connections at every piece of equipment. Work not correctly located shall be relocated at the Contractor's expense.
  3. It shall be the responsibility of each Contractor to leave the necessary room for other trades. No extra compensation or time will be allowed to cover the cost of removing fixtures, devices, conduit, ducts, etc. or equipment found encroaching on space required by others.
  4. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than  $\frac{1}{4}$  inch = 1 Foot, clearly indicating how his work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. The Contractor shall make the necessary changes in his work to correct the condition without extra charge.
  5. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

E. Temporary Services

1. The Contractor shall arrange for temporary electrical and other services required to accomplish the work. In the absence of other provisions in the contract, the Contractor shall provide for temporary services of all types, including the cost of connections, utility company fees, construction, removal, etc., in their bid.
2. All temporary services shall be removed by Contractor prior to acceptance of work.

F. Temporary Use of Equipment

1. The permanent electrical equipment, when installed, may be used for temporary services, subject to an agreement among the Contractors involved, the Owner, and with the consent of the Engineer. Should the permanent systems be used for this purpose, each Contractor shall pay for all temporary connections required and any replacements required due to damage without additional cost to the Owner, leaving the equipment and installation in "as new" condition. The Contractor may be required to bear utility costs, user fees, etc.
2. Permission to use the permanent equipment does not relieve the Contractors who utilize this equipment from the responsibility for any damages to the building construction and/or equipment which might result from its use.

G. Preinstallation Conference

1. Conduct a preinstallation conference at project site before each construction activity when required by other Sections and when required for coordination with other construction.
2. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Architect and Engineer of scheduled meeting dates.
3. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including any possible conflicts, requirements, limitations, and coordination with other work.
4. Record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.
5. Reporting: Distribute minutes of the meeting to each party present and to other parties requiring information.
6. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date

1.6 SUBMITTALS

- A. Review of submittals by the Engineer applies only to conformance with the design intent of the project and general compliance with the information given in the contract documents. In all cases, the installing Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located.
- B. The Engineer's review of submittals, schedules or other required submittal data shall not relieve the Contractor from responsibility for the adaptability of the equipment or materials to the project, compliance with applicable codes, rules, regulations, information that pertains to

fabrication and installation, dimensions and quantities, electrical characteristics, and coordination of the work with all other trades involved in this project.

- C. If a submittal deviates from the drawings or specifications because of Contractor's standard practice, approved substitution request, or any other reason, the submittal shall notify the designer of the deviation.
- D. Prior to the start of work the contractor shall submit the following. Work shall not proceed without the Engineer's and Owner's completed review of the submitted items.
- E. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.
  - 1. If information must be specially prepared for submittal because standard published data are unsuitable for use, submit as Shop Drawings, not as Product Data.
  - 2. Clearly and precisely mark red notations and yellow highlights on the submittal to show which products and options are applicable.
  - 3. Include the following information, as applicable:
    - a. Manufacturer's catalog cuts.
    - b. Manufacturer's product specifications.
    - c. Standard color charts.
    - d. Statement of compliance with specified referenced standards.
    - e. Testing by recognized testing agency.
    - f. Application of testing agency labels and seals.
    - g. Notation of coordination requirements.
    - h. Rated capacities, operating characteristics, and electrical characteristics,
    - i. Wiring diagrams that show factory-installed wiring and interface points.
    - j. Clearances required to other construction, if not indicated on accompanying Shop Drawings.
  - 4. Format and Organization: submit bookmarked electronic PDF files complying with the following:
    - a. Cover: Clearly display the following information: Owner name, Project name, Submittal name, project submittal number, Contractor name and contact information, and applicable specification section numbers.
    - b. Table of Contents: Include a TOC that lists materials by section number, with a brief product description, manufacturer and part number, and list the submittal page number per product
    - c. Product Information
- F. Product Schedules: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:
  - 1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
  - 2. Manufacturer and product name, and model number if applicable.
  - 3. Number and name of room or space.
  - 4. Location within room or space.

- G. Shop Drawings: Prepare Project-specific information, drawn accurately to scale.
1. Shop Drawings that are reproductions of the Contract Documents are not permitted and will be rejected.
  2. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
    - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
    - b. Mounting Details
    - c. Wiring diagrams and installation details
    - d. Identification of products.
    - e. Schedules.
    - f. Compliance with specified standards.
    - g. Notation of coordination requirements.
    - h. Notation of dimensions established by field measurement.
    - i. Seal and signature of professional engineer if specified.
- H. Coordination Drawings:
1. Detailed electronic coordination drawings shall be required for this project. The Engineer and the Engineer's Construction Administrator shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.
  2. Coordination Drawings shall be provided on this project by each Trade. Drawings shall be 30x42 sheet size and shall be at 1/4-inch scale and shall match the drawing setup as included in the Architectural Drawings. Drawings shall be prepared in electronic format utilizing AutoCad software. The Architect and Engineer will supply electronic drawings files of the Contract Documents upon the Contractor's request and release.
  3. The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits, groupings of branch circuit conduits, other conduits 2" and larger, and pneumatic tube system piping and components in ceiling spaces. These drawings shall indicate all ductwork as double lined with bottom elevations noted. The Coordination Drawings shall indicate:
    - a. Systems above ceilings in finished areas,
    - b. Systems supported from the structure in finished areas without ceilings,
    - c. Systems in the mechanical rooms, and
    - d. All wall, roof, floor penetrations.
  4. The sheet metal fabrication shop drawings shall be completed in a timely manner so as not to conflict with construction schedule and phasing plan. At the Prime Contractor's discretion, these drawings shall be completed in phases to correspond with the project construction work sequencing. The Mechanical Contractor shall furnish an electronic copy of these ductwork shop drawings to all other Trades, specifically the Fire Protection and Electrical and other Contractors as requested by the Prime Contractor for the purpose of including other trades work on the Coordination Drawings.
  5. Pre-Coordination Meetings with all necessary trades shall occur. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc. will be installed with respect to the sheet metal fabrication drawings and other trades. The sheet metal ductwork and gravity piping systems shall be given the first priority.

Within 30 days of the meeting, each Trade shall provide the Mechanical Contractor electronic drawings of all of their systems (with elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings shall then occur so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at these Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.

6. It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
  - a. All supply/return/exhaust ductwork.
  - b. All above slab sanitary and roof drainage piping.
  - c. HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
  - d. Gas mains.
  - e. Electrical conduits which are 1.5" in size and greater.
  - f. J-hook and cable tray cabling paths
  - g. Groupings of smaller piping/conduits hung on a common hanger.
  - h. All wall, roof, floor penetrations.
  - i. Light fixtures.
7. After completion of the Final Coordination Drawings, a Final Review with the all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meeting will be required to ensure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed electronically (on CD) to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete 30x42 paper set of drawings to the jobsite main office and shall utilize them for updates of field conditions/deviations that occur during construction. Final Approved Coordination Drawings shall also be distributed to the Construction Manager, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.
8. Each Contractor shall ensure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on record drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Construction Manager, Owner, Architect and Engineer for their Records.
9. The Mechanical Contractor is responsible to the Prime Contractor for the shop drawing layout of the following rooms and details:
  - a. Concrete pads and foundations
  - b. Equipment room layouts with actual equipment
  - c. Roof layouts
  - d. Trench locations and sizes
  - e. Dimensioned floor drain locations
  - f. Congested areas above ceilings adjacent to mechanical and electrical rooms
  - g. Dimensioned ductwork shop drawings

10. The Electrical Contractor is responsible to the General Contractor for the shop drawing layout of the following rooms and details:
  - a. Concrete pads and foundations
  - b. Equipment room layouts with actual equipment
  - c. Routes of feeder conduits and all other conduits 1.5" and larger
  - d. J-hook and cable tray cabling paths
  - e. Trench locations and sizes
  - f. Congested areas above ceilings adjacent to mechanical and electrical rooms
  - g. Light fixture locations
  - h. Exact layouts of all work in open ceiling areas
- I. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of architects and owners, and other information specified.
- J. Closeout Submittals
  1. Upon substantial completion of the project, provide a minimum of three bound copies with complex index and tabs to locate each item described below along with digital copy in PDF format on USB storage media.
  2. As-Built Record Documentation
    - a. The Contractor shall insure that any deviations from the design are being recorded daily, as necessary, on record drawings being maintained by the Contractor. Dimensions from fixed, visible permanent lines or landmarks shown in vertical and horizontal ways shall be utilized. Compliance shall be a requirement for final payment. Pay particular attention to the location of underfloor or underground exterior in-contract or utility-owned or leased service lines, main switches, and other appurtenances important to the maintenance and safety of the Electrical System. Deliver these record drawings to the Engineer as a system is completed, within ten days of the mark-up and/or while the accuracy of the mark-ups can be verified visually. Monthly payment may be withheld if the requirement is not complied with.
    - b. All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State where the Work is being performed. This shall include underground electrical primary, communications, and structures. The survey shall include actual duct bank depths to top of conduit every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on electronic storage media in AutoCad ".dwg" format and ".pdf" format. The survey information shall be included in the closeout documentation.
    - c. Refer to additional record drawing requirements within the general conditions and other sections of these specifications.
  3. Start-Up and System Testing Certificates
    - a. Provide reports from all required testing to indicate procedures followed and complete results of all tests. Provide reports on manufacturer's standard forms for all equipment and system tests. Testing reports shall indicate applicable NEC, NFPA, UL, NETA, and/or ANSI standards.

4. Operation and Maintenance Manuals
  - a. Provide operation and maintenance instructions and parts lists for all equipment provided in this contract. Formatting and content shall follow the guidelines outlined in the latest version of ASHRAE Application Handbook, Guideline.
  - b. All instructions shall be submitted in draft, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions.
  - c. The operation and maintenance document directory should provide easy access and be well organized and clearly identified.
  - d. The operation and maintenance manuals shall contain the following information:
    - 1) Emergency information should be immediately available during emergencies and should include emergency and staff and/or agency notification procedures.
    - 2) Provide contacts (company name, address, phone number, email) where parts may be purchased for each principal item of equipment.
    - 3) Provide detailed maintenance instructions, including recommended preventative maintenance schedules for all equipment requiring maintenance. For lighting and lighting controls, provide recommended driver replacement schedule, provide a schedule for inspecting and recalibrating lighting controls, and provide a recommended settings list for all components with adjustable settings.
    - 4) General Information. Provide the following:
      - a) Building function
      - b) Building description
      - c) Operating standards and logs
    - 5) Technical Information. Provide the following:
      - a) System description
      - b) Operating routines and procedures
      - c) Seasonal start-up and shutdown
      - d) Special procedures
      - e) Basic troubleshooting
    - 6) Equipment data sheets. Provide the following:
      - a) Vendor and local representative's contact information
      - b) Operating and nameplate data
      - c) Warranty
      - d) Detailed operating instructions.
      - e) Tools required
      - f) Types of cleaners to use
    - 7) Maintenance program information. Provide the following:
      - a) Manufacturer's installation, operation, and maintenance instructions
      - b) Spare parts information
      - c) Preventive maintenance actions
      - d) Schedule of actions
      - e) Action description
      - f) History
    - 8) Test reports document observed performance during start-up and commissioning.
    - 9) Reference Division 01 specifications for additional requirements.

- e. Shop drawings will not be accepted as satisfying the requirement for Operation and Maintenance Manuals.
  - f. Submittals: Provide complete copies of all reviewed submittals. Where submittals were returned "Furnish as Corrected", the contractor shall make the corrections noted by the engineer and submit final corrected shop drawings with close-out documentation.
  - g. Parts List: Provide an inventory of all spare parts, special tools, attic stock, etc. that have been provided to the owner.
- 5. Warranty Documentation: Provide all documentation and certificates related to Contractor's warranty and all other specific manufacturer's warranties indicated in the construction documents.
  - 6. Training Verification: Provide certification that all specified training has been completed. List training session dates, times, and types. Include any session materials and recordings.
  - 7. Inspection Certificates: Provide certificates of inspection from electrical inspector, fire marshal, and any other required special inspections.
  - 8. Reports and System Certifications: Provide final reports and any system certifications required in other specification sections.
  - 9. Power Riser Diagram: Provide a framed and mounted full-size copy of the overall power riser diagram (under glass) to the Owner. Also, provide three vinyl-coated copies of same. Where an existing power riser diagram is present, the Contractor shall obtain the document from the Owner, and update in digital format with the scope of this project. Edits shall be in digital format and this work shall be closely coordinated with the Owner.
  - 10. Software and Firmware Operational Documentation: Provide documentation, including the following:
    - a. Software operating and upgrade manuals.
    - b. Names, versions, and website addresses for locations of installed software.
    - c. Device address list.
    - d. Printouts of software application and graphic screens.
  - 11. Software Back-ups: Provide software back-ups on USB media that is clearly and permanently labeled and provided with lanyard to prevent misplacement.

## 1.7 MAINTENANCE MATERIAL

### A. Spare Parts and Extra Stock Material

- 1. Parts and Materials shall be properly marked and packaged for long-term storage.

### B. Special Tools and Keys:

- 1. Provide, along with the equipment provided, any special wrenches or tools necessary to dismantle or service equipment or appliances.
- 2. Wrenches shall include necessary keys, handles and operators for valves, switches, breakers, etc. and keys to electrical panels, emergency generators, alarm pull boxes and panels, etc.
- 3. Provide at least two of any such special wrench, keys, etc. to the Owner prior to completion of the project. Obtain a receipt that this has been accomplished and forward a copy to the Architect and Engineer.



## 1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of five years unless otherwise approved.
1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
  2. Equipment shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.
- B. Installer Qualifications
1. All Electrical Contractors bidding this project must have been a licensed company for a minimum of three years to qualify to bid this project. Individual employee experience does not supersede this requirement.
  2. All subcontractors bidding the electrical work must have completed one project of 70 percent this subcontract cost size and two projects of 50 percent this subcontract cost size.
  3. All electrical work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers as evidenced by their workmanship shall be relieved of their responsibilities in those areas. The Engineer shall reserve the right to determine the quality of workmanship of any worker and unqualified or incompetent workers shall refrain from work in areas not satisfactory to them. Requests for relief of a worker shall be made through the normal channels of responsibility established by the Architect or the contract document provisions.
  4. All electrical work shall be accomplished by Journeymen electricians under the direct supervision of a licensed Electrician.
  5. Special electrical systems, such as Fire Alarm Systems, Telecommunications or Data Systems, Video Systems, Special Electronic Systems, Control Systems, etc., shall be installed by workers normally engaged or employed in these respective trades. Refer to Divisions 27 and 28 for additional requirements.
- C. Licensed Professional Engineer Qualifications: Professional Engineer possessing active qualifications in accordance with Division 01 and licensed by the State in which the Work is being performed.

## 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver or install indoor equipment until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above equipment is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

## 1.10 FIELD CONDITIONS

### A. Ambient Conditions:

1. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - a. Ambient Temperature: Not exceeding 104 deg F.
  - b. Altitude: Not exceeding 6600 feet.

## 1.11 WARRANTIES

- A. Contractor Warranty: Contractor shall unconditionally guarantee all equipment, apparatus, materials, and workmanship entering into this Contract to be the best of its respective kind and shall replace all parts at their own expense, which fail or are proven defective within one year from Substantial Completion of the work by the Engineer. The effective date of completion of the work shall be the date each or any portion of the work is accepted by the Architect, Engineer, and Owner's Statement of Substantial Completion.
- B. Manufacturer Warranty: Items of equipment which have longer guarantees, as called for in these specifications or as otherwise offered by the manufacturer shall have warranties and guarantees completed in order and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall in no way invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period due to negligence of his operator or other employee.
- C. The Warranties specified herein and other Sections shall not deprive the Owner of other rights the Owner may have under provisions of the Contract Documents and shall be in addition to, and run concurrently with other warranties made by the Contractor under requirements of the Contract Documents.

## 1.12 INDEMNIFICATION

- A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

## 1.13 HAZARDOUS MATERIALS

- A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building(s). Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as

a part of their work, ensure their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

- B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling, or disposal of such material.
- C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner immediately.
- D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency suitable to the AHJ, and marked for intended location and application.
- B. Materials used shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards, other applicable federal, state, and local laws.
- C. Standard Products
  - 1. Except where specifically noted otherwise, all equipment supplied by the Contractor shall be the standard products of a single manufacturer of known reputation and experience in the industry.
  - 2. Only equipment, components, and accessories in current production for at least five years beyond the completion date of this system shall be used and installed. Any equipment found to be obsolete or not in future production will be removed and replaced at Contractor's expense. This includes all equipment, materials and labor.
  - 3. Products manufactured more than 2 years prior to date of delivery to site shall not be used, unless specified otherwise.
- D. Product numbers are subject to change by the manufacturer without notification. In the event a product number is invalid or conflicts with the written description, notify the Engineer in writing prior to ordering the material and performing installation work.

## 2.2 PRODUCT SUBSTITUTIONS

- A. Conform to the substitutions requirements and procedures outlined in Division 01.
- B. One substitution for each product specified will be considered and substitutions must be submitted to Engineer a minimum of 10 days prior to bid using the standard CSI substitution request form.
- C. If prevailing laws of cities, towns, states or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.
- D. Where products are noted as "or equal", a product of equivalent design, manufacture, and performance will be considered. Submit product data (product information, catalog cut sheets, test data, etc.) to substantiate that the product is in fact equivalent to that specified. The burden of proof that the substituted product is equivalent to the specified product rests with the Contractor. Whenever material, process or equipment is specified in accordance with an industry specification (ANSI, TIA, etc), UL rating, or other association standard, present an affidavit from the manufacturer certifying that the product complies with the particular standard specification. When requested by the Engineer, submit supporting test data to substantiate compliance.
- E. Manufacturers' names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish standards of quality, utility and appearance and shall not be construed as limiting competition. Materials, processes, or equipment that, in the opinion of the Engineer, are equivalent in quality, utility and appearance will be approved as substitutions to that specified when "or equal" follows the manufacturers' names or model number(s).
- F. When the Engineer accepts a substitution in writing, it is with the understanding that the Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Do not provide substituted material, processes, or equipment without written authorization from the Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by the Engineer, are at the sole risk of the Contractor.
- G. Approved substitutions shall not relieve the Contractor of responsibilities for the proper execution of the work, or from provisions of the specifications.
- H. Contractor shall pay expenses, without additional charge to the Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on their work or other Contractor's work.
- I. In all cases where substitutions affect other trades, the Contractor offering such substitutions shall advise all such Contractors of the change and shall reimburse them for all necessary changes in their work. Any Drawings, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not absolve the Contractor of this responsibility.

- J. Contractor shall be responsible and assume all costs for removal and replacement of any substituted product installed without prior written approval. Such costs shall include, but not be limited to labor, materials as well as any penalties, fees or costs incurred for late completion.

### PART 3 - EXECUTION

#### 3.1 INSTALLERS

- A. Supervision of Work: Each Contractor and Sub-Contractors shall personally supervise the work or have a competent superintendent on the project site at all times during progress of the work, with full authority to act in matters related to the project.
- B. Conduct of Workmen: The Contractor shall be responsible for the conduct of all workmen under their supervision. Misconduct on the part of any workmen to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt relief of that workman. The consumption or influence of alcoholic beverages, narcotics or illegally used controlled substances on the jobsite is strictly forbidden. Possession of a fire-arm is prohibited and may result in prosecution. Foul or bad language, graffiti is strictly prohibited.

#### 3.2 EXAMINATION

- A. Each Contractor shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. All Contractors shall carefully examine all Drawings and Specifications and inform themselves of the kind and type of materials to be used throughout the project and which may, in any way, affect the execution of their work.
- B. Each Contractor shall fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of temporary or permanent utilities, etc. The Contractor shall include in their work all expenses or disbursements in connection with such matters and conditions. Each Contractor shall verify all work shown on the drawings and conditions at the site and shall report in writing to the Engineer ten days prior to bid, any apparent omissions or discrepancies in order that clarifications may be issued by written addendum. No allowance is to be made for lack of knowledge concerning such conditions after bids are accepted.

#### 3.3 PREPARATION

- A. Surveys, Measurements, and Grades
  - 1. The Contractor shall lay out their work and be responsible for all necessary lines, levels, elevations, and measurements. They must verify the figures shown on the drawings before laying out the work and will be held responsible for any error resulting from their failure to do so.

2. Base all measurements, both horizontal and vertical, from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the work.
3. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and specifications, they shall notify the Engineer through normal channels of job communication and shall not proceed with his work until they have received instructions from the Engineer.

### 3.4 INSTALLATION

- A. At no time shall the contractor work on energized electrical equipment. Contractor shall comply with NFPA 70E requirements at all times throughout construction.
- B. Permits and Fees
  1. The Contractor shall give all necessary notices, obtain, and pay for all permits, government sales taxes, fees, and other costs in connection with their work. As necessary, the Contractor shall file all required plans, utility easement requests and drawings, survey information on line locations, load calculations, etc., prepare all documents and obtain all necessary approvals of all utility and governmental departments having jurisdiction; obtain all required certificates of inspection for their work and deliver same to the Engineer before request for final acceptance and final payment for the work.
  2. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.
- C. Codes and Regulations
  1. The Contractor shall include in the work, without extra cost, any labor, materials, services, apparatus, or drawings required in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on drawings and/or specified.
  2. All materials furnished and all work installed shall comply with the adopted edition of the National Electrical Codes, National Fire Codes of the National Fire Protection Association, the requirements of local utility companies, and with the requirements of all governmental agencies or departments having jurisdiction.
  3. All electrical work is to be constructed and installed in accordance with plans and specifications which have been approved in their entirety and/or reflect any changes requested by the AHJ, as applicable or required. Electrical work shall not commence until such plans are in the hands of the Electrical Contractor.
  4. The Contractor shall insure their work is accomplished in accord with OSHA Standards and any other applicable government requirements.
  5. Where conflict arises between any code and the contract documents, the code shall apply except in the instance where the plans and specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten working days prior to bid date, otherwise the Contractor shall make the required changes at their own expense. The provisions of the codes constitute minimum standards for wiring methods, materials, equipment and construction and compliance therewith will be required for all electrical work, except where the drawings and specifications require better materials, equipment, and construction than these

minimum standards, in which case the drawings and specifications shall be the minimum standards.

D. Materials and Workmanship

1. All electrical equipment, materials and articles incorporated in the work shall be new and of equal quality to the specified basis of design. All workmanship shall be first-class and shall be performed by electricians skilled and regularly employed in their respective trades.
2. The Contractor shall determine that the equipment he proposes to furnish can be brought into the building(s) and installed within the space available. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s).
3. All fixtures, devices and wiring required shall be installed to make up complete systems as indicated on the drawings and specified herein.
4. All electrical materials, equipment and appliances shall conform to the latest standards of the National Electric Manufacturers Association (NEMA) and the National Board of Fire Underwriters (NBFU) and shall be approved by the Owner's insuring agency if so required.
5. Comply with National Electrical Contractors Association (NECA) performance standards that are published as National Electrical Installation Standards (NEIS).
6. All applicable equipment and devices provided shall meet all FCC requirements and restrictions.

E. Weatherproofing

1. Where any work penetrates waterproofing, including waterproof concrete, the method of installation shall be as approved by the Architect and/or Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings absolutely watertight.
2. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

F. Equipment Access

1. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in partitions and above suspended ceilings for the proper installation of their work. Cooperate with the Prime Contractor and all other Contractors whose work is in the same space and advise each Contractor of equipment requirements. Such spaces and clearances shall be kept to the minimum size required to ensure adequate clearance and access.
2. The Contractor shall locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment shall include but not be limited to junction boxes, pull boxes, contactors, panels, disconnects, controllers, switchgear, etc. Minor deviations from drawings may be made to allow for better accessibility, and any change shall be approved where the equipment is concealed.
3. Each Contractor shall provide (or arrange for the provision by other trades) the access panels for each concealed junction box, pull box, fixtures or electrical device requiring access or service as shown on Engineer's plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. All

access panels shall be installed in accord with the Architect's standards for such work. In the absence of such specifications, at a minimum such work shall comply with the specifications below. All locations for access panels which are not specifically indicated on the drawings shall be submitted to and approved by the architect prior to ordering.

4. Access Doors; in Ceilings or Walls:
  - a. In mechanical, electrical, and service spaces: 14-gauge aluminum brushed satin finish, 1" border.
  - b. In finished areas: 14-gauge primed steel with 1" border to accept the architectural finishes specified for the space. Confirm these provisions with the Architect prior to obtaining materials or installing any such work.
  - c. In fire or smoke rated partitions, access doors shall be provided that equal or exceed the required rating of the construction they are mounted in.

G. Connections

1. Provide rough-in and final connections to all electrically operated equipment furnished under the Work of the contract documents. Carefully coordinate with equipment suppliers, manufacturer's representatives, vendors, and other trades to provide complete electrical and dimensional interface to all equipment.
2. Provide all power wiring complete from power source to motor or equipment junction box, including power wiring through starters or contactors. Install all starters not factory mounted on equipment.
3. Provide all control, interlock, sensor, thermocouple, and other connections required for equipment operation. Coordinate ampacity and voltage characteristics for all motors and equipment.
4. Prior to bidding the work, coordinate power, control, sensor, interlock and all other wiring requirements for equipment or motors with all other trades, to ensure all needed wiring is provided. Failure to provide such coordination shall not be justification for claims of extra compensation of a time extension to the Contract.
5. At no times shall the contractor work on energized electrical equipment. Comply with NFPA 70E requirements at all times during construction.

- H. Scaffolding, Rigging, and Hoisting: The Contractor shall furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

### 3.5 RESTORATION

- A. The Contractor shall replace to their original condition all paving, curbing surfaces, drainage ditches, structures, fences, shrubs, existing or new building surfaces and appurtenances, and any other items damaged or removed by his operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item to be replaced. All repairs shall be to the satisfaction of the Engineer, and in accord with the Architect's standards for such work, as applicable. Patchwork on new construction will not be accepted.



### 3.6 IDENTIFICATION AND OPERATING INSTRUCTIONS

- A. Provide all equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.
- B. Provide operating instructions for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:
  - 1. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
  - 2. Start up, proper adjustment, operating, lubrication, and shutdown procedures.
  - 3. Safety precautions.
  - 4. The procedure in the event of equipment failure.
  - 5. Other items of instruction as recommended by the manufacturer of each system or item of equipment.
- C. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

### 3.7 SYSTEM TESTING, VERIFICATION, AND START-UP

- A. The Contractor (and Sub-Contractors) shall be responsible for starting-up, testing, checking, examining, inspecting, and verifying their systems.
- B. The Electrical Contractor shall designate an individual under their employment to lead the start-up, testing and verification process. This person should not be the project manager or job site superintendent, but a person dedicated to making this critical task successful and completed in a timely manner.
- C. A pre-start-up conference shall be held with the Architect, Owner, Contractors, and the Manufacturer providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.
- D. The Contractor shall include in the bid to provide systems startup and verification for all electrical systems specified for this project. Specific startup, testing, and verification requirements are included throughout the Electrical specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians (unless noted otherwise) and shall complete and submit start-up reports/checklists. Submit start-up reports to the Engineer. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner.
- E. Where manufacturer start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up in strict accordance with manufacturer's instructions.

- F. The Contractor shall be responsible for completion of a System Verification Checklist (SVC) / Manufacturer's Checklists. Furnish to the Testing Agent and Engineer. Sample checklists shall be submitted to the Engineer, Owner, and Testing Agent for approval.
- G. The completed reports shall be organized and bound together in a tabbed binder and submitted for review and approval.

### 3.8 FIELD QUALITY CONTROL

#### A. Inspections

- 1. Before requesting a final review of the installation from the Architect and/or Engineer, the Contractor shall thoroughly inspect the installation to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineers for unnecessary and undue work on their part.
- 2. Owner's and Engineer's inspections: Two inspections will be held to generate and then review punchlist items. All site inspections and visits thereafter shall be billed to the Contractor at the Engineer's standard hourly rates.
- 3. The Contractor shall provide as a part of this contract electrical inspection by a competent Electrical Inspection Agency (local or state as specific to project), licensed to provide such services. The name of this agency shall be included in the list of materials of the Form of Proposal by the Contractor. All costs incidental to the provision of electrical inspections shall be borne by the Electrical Contractor.
- 4. The Contractor shall advise each Inspection Agency in writing (with an information copy of the correspondence to the Architect and/or Engineer) when they anticipate commencing work. Failure of the Inspection Agency to inspect the work in the stage following and submit the related reports may result in the Contractor's having to expose concealed work not so inspected. Costs associated with any rework, cutting, and patching will be at the expense of the responsible Contractor.
- 5. Inspections shall be scheduled for rough-in as well as finished work. The rough inspections shall be divided into as many inspections as may be necessary to correct deficiencies. Report of each such inspection visit shall be submitted to the Architect, Engineer, and the Contractor within three days of the inspection.
- 6. Approval by an Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these plans and specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.
- 7. Before final acceptance, the Contractor shall furnish three copies of the certificates of final approval by the Electrical Inspector (as well as all other inspection certificates) to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

#### B. Punch Lists

- 1. The Contractor shall review each area and prepare a punch list for each of the subcontractors, as applicable, for at least three stages of the project.
  - a. For review of in-wall work that will be concealed by drywall or other materials well before substantial completion.

- b. For review of the above-ceiling work that will be concealed by tile or other materials well before substantial completion.
  - c. For review of all other work as the project nears substantial completion.
- 2. When all work from the Contractor's punch list is complete at each of these stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing two weeks prior to the proposed date.
- 3. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review.
- 4. At the engineer's option, the contractor shall supply digital photographs via email or file-share of any installed work.
- 5. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due 10 days from date of each additional visit) at a rate of \$125.00 per hour for extra trips required to complete either of the above-ceiling or final punch lists.
- 6. All panelboard fronts shall be removed prior to final punch list inspection and re-installed after completion. Directories for each panelboard shall be completed and available for review by the Engineer at that time.

### 3.9 CLEANING

- A. The Contractor shall, at all times, keep the area of work presentable to the public and clean of rubbish caused by their operations; and at the completion of the work, shall remove all rubbish, all tools, equipment, temporary work and surplus materials, from and about the premises, and shall leave the work clean and ready for use. If the Contractor does not attend to such cleaning immediately upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the responsible Contractor. Each Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of rubbish or debris.
- B. After completion of all work and before final acceptance of the work, each Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of materials, equipment, and all associated fabrication. Pay particular attention to finished area surfaces such as lighting fixture lenses, lamps, reflectors, panels, etc.

### 3.10 TRAINING

- A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating all systems and equipment for a period of three days of eight hours each, or as otherwise specified. During this period, instruct the Owner or their representative fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least one week's written notice to the Owner, Architect and Engineer in advance of this period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representative that were present.

- B. Training shall be accompanied by complete as-built documentation and the technical systems operation manual.
- C. The training shall be accomplished by a factory trained representative. Include a minimum of Four hours for each system described here-in unless noted otherwise. Each equipment representative shall be represented wherever their equipment is used.
- D. Demonstration and Training DVDs: These training sessions shall be videotaped by the Installer. Submit two copies within seven days of end of each training module. On each copy, provide an applied label with the following information:
  - 1. Name of Project.
  - 2. Name and address of photographer.
  - 3. Name of Architect and Construction Manager.
  - 4. Name of Contractor.
  - 5. Date video was recorded.
- E. Brochures: Furnish Owner a complete set of operating instructions and diagrams.
- F. Instruction Program: Submit outline of instructional program for demonstration and training, including a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.
- G. At completion of training, submit two complete training manual(s) for Owner's use.
- H. Qualification Data: For facilitator, instructor and photographer.
- I. Attendance Record: For each training module, submit list of participants and length of instruction time.

### 3.11 PROTECTION

- A. The Contractor shall be entirely responsible for all material and equipment furnished for their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. Equipment damaged while stored on site either before or after installation shall be repaired or replaced (as determined by the Engineer) by the responsible Contractor. Electrical equipment exposed to the weather shall be replaced by the Contractor at their own expense.

END OF SECTION 260010

## SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Slotted Support Systems.
  - 2. Conduit and Cable Supports.
  - 3. Mounting, Anchoring, and Attachment Components.
  - 4. Fabricated Metal Supports.
  - 5. Concrete Bases.
  - 6. Vibration Isolation pads.
  - 7. Sleeves for penetration of non-fire-rated construction walls and floors.
  - 8. Sleeve-seal systems.
  - 9. Firestopping.
  - 10. Cutting and Patching
  - 11. Painting

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. EMT: Electrical Metallic Tubing.
  - 2. FMC: Flexible Metal Conduit.
  - 3. GRC/GRS: Galvanized Rigid Steel Conduit.
  - 4. LFMC: Liquid-tight flexible metal conduit.
  - 5. RMC: Rigid Metal Conduit
- B. Definitions
  - 1. Channel: A continuous slotted channel (strut) with inturned lips suitable for assembly into multiple configurations
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. Metal Framing Manufacturers Association (MFMA)
    - a. MFMA-4: Metal Framing Standards Publication
    - b. MFMA-103: Guidelines for the use of Metal Framing

#### 1.4 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations with Division 07 Section "Roof Accessories."

#### 1.5 SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of components, profiles, and finishes.
  - 2. Include rated capacities.
- B. Shop Drawings: For fabrication and installation details and include calculations for the following:
  - 1. Slotted channel systems.
  - 2. Equipment supports.
  - 3. Concrete Bases for Equipment.
  - 4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal: Signed and sealed by a qualified professional engineer. For field assembled or fabricated hangers and supports for electrical systems.
  - 1. Include design calculations and details of trapeze hangers.
- D. Qualification Data: For professional engineer.

#### 1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to the authority having jurisdiction, and marked for intended location and application.
- B. Delegated Design: Design support systems, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

## 2.2 SLOTTED SUPPORT SYSTEMS

- A. Description: Preformed, continuous slot, bolted channels with associated fittings and hardware.
1. Available Manufacturers: Subject to compliance with requirements, provide products from one of the following or an approved equal:
    - a. Eaton B-Line.
    - b. Kindorf.
    - c. nVent Caddy.
    - d. Power-Strut.
    - e. SuperStrut.
    - f. Unistrut.
  2. Comply with MFMA-4 for factory fabricated components suitable for field assembly.
  3. Material and Finish for channel, fittings, and accessories:
    - a. Steel: Minimum 16 gauge, Hot-dip galvanized after fabrication and applied according to ASTM A123 or A153 suitable for indoor or outdoor wet locations.
  4. Channel Dimensions: Minimum 1-5/8 inches wide with varying heights and welded combinations selected to meet applicable load criteria.

## 2.3 CONDUIT AND CABLE SUPPORTS

- A. Available Manufacturers: Subject to compliance with requirements, provide products from one of the following or an approved equal:
1. Eaton B-Line
  2. nVent Caddy
  3. Thomas & Betts
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Provide plugs with number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported.
- D. Device Box Mounting Brackets: Factory-fabricated sheet steel brackets for support of device boxes adjacent to or between studs.
- E. Through-Stud Cable and Raceway Support Clips: Factory-fabricated spring steel clip for cables or raceways where run horizontally through metal studs.
- F. Roof-mounted Raceway Support Blocking: Non-penetrating, factory-fabricated support blocking for use under roof-mounted raceways. Wedge-shaped blocking constructed of 100% recycled UV-resistant Rubber with integral galvanized steel strut to accept raceway support clips.

- G. Tee Bar Grid Box Hanger: Factory-fabricated metal electrical box hanger for supporting boxes at locations between ceiling system t-grid components. Height adjustable for various electrical box depths. Attached to ceiling tee bar with screws or integral clamp for stability. Includes tab for independent support wire attachment.

## 2.4 MOUNTING, ANCHORING, AND ATTACHMENT COMPONENTS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Eaton B-Line
  - 2. Empire Industries.
  - 3. Hilti.
  - 4. ITW.
  - 5. MKT Fastening.
- B. Description: Items for fastening electrical items or their supports to building surfaces include the following:
  - 1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
  - 2. Concrete Inserts: Steel, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
  - 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  - 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
  - 5. Toggle Bolts: All-steel springhead type.
  - 6. Hanger Rods: Solid, threaded steel.

## 2.5 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

## 2.6 VIBRATION ISOLATION PADS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Korfund Maxi-Flex Pads or a comparable product by one of the following:
  - 1. Ace Mountings Co.
  - 2. California Dynamics Corporation.
  - 3. Eaton B-Line.
  - 4. Kinetics Noise Control.
  - 5. Mason Industries.
  - 6. Vibration Eliminator Co.



7. VMC Group

- B. Description: Molded, oil resistant, non-skid elastomeric pads arranged in 2-inch square segments.
- C. Size: Factory or field cut to match requirements of supported equipment.
- D. Load Rating from 120 lbs. up to 360 lbs. per 2-inch segment.

2.7 SLEEVES

- A. Wall and Floor Sleeves:
  - 1. Galvanized Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

2.8 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable. Link Seal system or approved equal.
  - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Glass reinforced nylon polymer.
  - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.9 FIRESTOPPING FOR ELECTRICAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products from one of the following or approved equal:
  - 1. Hilti
  - 2. Specified Technologies Inc (STI)
  - 3. Wiremold
- B. Source Limitations: Obtain firestopping systems through one source from a single manufacturer.
- C. General Requirements:
  - 1. Firestopping systems shall bear UL classification marking corresponding to its Fire Resistance Directory.
  - 2. Comply with testing requirements set forth in ASTM E814 or UL 1479.
  - 3. Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.
  - 4. Provide components for each through-penetration firestop system that are needed to install fill materials. Use only components specified by the firestopping manufacturer

and approved by the qualified testing agency for the designated fire-resistance-rated systems.

- D. Fire rated cable pathways: Re-penetrable, maintenance-free cable management devices for use with cable bundles penetrating through fire rated walls or floors.
  - 1. Shall contain a built-in fire sealing system sufficient to maintain the hourly rating of the fire rated wall or floor being penetrated.
  - 2. The system shall adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to remove or reinstall firestop materials.
  - 3. Shall be engineered to allow two or more devices to be ganged together with wall plates for larger cable capacities.
- E. Fire-rated cable grommets: Molded, two-piece grommet with sealing membrane for use with single cables or small bundles at through or membrane wall penetrations.
  - 1. System shall be installed around cables and shall lock tightly into the wall assembly.
- F. Outlet Box Putty Pads: Non-hardening, moldable, intumescent material shaped into preformed pads for use with metallic outlet boxes.
- G. Refer to Division 07 for requirements related to other firestopping systems and materials.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation devices for compliance with manufacturer's installation requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 CUTTING AND PATCHING

- A. Unless otherwise indicated, provide cutting and patching necessary to install the work specified. Patching shall match adjacent surfaces to the satisfaction of the Engineer and shall be in accordance with the Architect's standards for such work.

- B. Do not cut structural elements without reinforcing the structure to maintain the designed weight bearing and stiffness. Coordinate approved reinforcement method with Architect and Structural Engineer.

### 3.3 SUPPORT SYSTEM APPLICATION

- A. Comply with NFPA 70, NECA 1, NECA 101, and MFMA-103 for application of hangers and supports for electrical equipment and systems except where requirements of this Section are more stringent.
- B. Maximum Horizontal and Vertical Support Spacing for Raceway(s): Space supports for raceways as required by NFPA 70.
- C. Minimum Hanger Rod Size for Raceway Supports: 3/8-inch diameter unless noted otherwise.
- D. Single Raceways:
  - 1. For Raceways 1-1/4-inch and smaller: Install adjustable steel band hanger suspended on threaded rod.
  - 2. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/4-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- E. Multiple Raceways and single raceways larger than 1-1/4-inch:
  - 1. Install trapeze-type supports fabricated with slotted support system suspended on threaded rods for horizontal applications and fastened to building structure for vertical applications.
  - 2. Size so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 3. Secure raceways and cables to these supports with two-bolt steel conduit clamps or single-bolt steel conduit clamps using spring friction action for retention in support channel.

### 3.4 SUPPORT SYSTEM INSTALLATION

- A. Comply with NFPA 70, NECA 1, NECA 101, and MFMA-103 for installation requirements except where requirements of this Article are more stringent.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components multiplied by a safety factor of four with a minimum of 200 lbs.
- C. Mounting and Anchorage of Surface-Mounted or Recessed-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.

- a. Where support anchors are required, establish their type and locate in concrete construction before concrete is poured. Fit each hanger rod with a nut at its upper end, and set nut in a universal concrete insert in the form. Where supported weight exceeds holding strength of a single insert, pass rods through top slot of inserts and interlock with reinforcing steel. Also, where particularly heavy loads are to be supported, suspend hanger rod or rods from a structural angle spanning two or more inserts and securely bolted thereto to distribute the weight.
  3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  4. To Existing Concrete: Self-drilling concrete anchors or expansion anchor fasteners.
  5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
  6. To Light Steel: Sheet metal screws.
  7. For Surface-Mounted Items on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to structure. Attachment to gypsum wall board is not acceptable as sole support means; slotted-channel rack solidly attached to structure or light-gauge metal framing at both ends is required.
  8. For Recessed-Mounted Items in Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices to intermediate light-gauge metal framing members on each side of device or provide slotted-channel racks within hollow wall attached to structure by means that meet anchorage requirements. Attachment to gypsum wall board is not acceptable as sole support means.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars or existing raceways embedded in slab. Verify reinforcing locations with Structural Engineer and X-Ray existing concrete structures as required.
- E. Do not support items such as equipment, piping, conduit, and other similar items that exceed 2 inches in diameter from the bottom of slabs. Where intermediate support is required between structural members, use slotted steel channels support systems attached to beams or joists to avoid attachment to slabs.
- F. Slotted Support Systems
1. Install slotted channel systems level and plumb.
  2. Remove burrs from all exposed cut edges prior to installation.
- G. Wall Stud and Ceiling Supports
1. Fasten junction, pull and devices boxes securely to the building construction, independent of raceway system.
  2. Install Device Box Mounting Brackets supported between two studs. Attach all device boxes to two studs, device box stabilizers are prohibited.
  3. Install Tee Bar Grid Box Hanger supported between two ceiling grid tee bars where devices boxes are located flush in recessed suspended ceilings. Install at least one independent support rod from box hanger to structure.
  4. Install Through-Stud Cable and Raceway Support Clips where cables or raceways run horizontally through metal studs.

- H. Install Roof-mounted Raceway Support Blocking where raceways run on across roofing.
  - 1. Coordinate installation of roof supports with items specified in Division 07 Section "Roof Accessories." Provide products compatible with rooftop materials included in the Work to maintain warranty of roof system.
- I. Threaded Rod Hardware
  - 1. Provide minimum of two lock nuts per threaded support rod except where lock nut tightens against a threaded socket, one locknut may be used.
  - 2. Trim rod excess to within 1-inch of locknut, de-burr, and provide protective endcap.
- J. Support raceways at a distance above suspended ceilings to permit removal of ceiling panels and luminaires.
- K. Locate raceways and supports so as not to hinder system functions or code required equipment clearances.
- L. Provide independent supports and hang all electrical raceways and devices from the building structure with UL listed and approved materials. Utilizing the support systems of other trade's work is prohibited, except with written approval from the Engineer.
- M. Provide riser support clamps for vertical conduit runs and install at each floor level penetration and at additional locations required to support weight of system.
- N. Tighten all bolted connections to proper torque values in accordance with manufacturer's written instructions.
- O. Provide supports to maintain 1/4-inch air space between raceway and mounting surface where raceways are mounted exposed in wet or corrosive locations and where directly attached to concrete or masonry.
- P. The use of tie wire or perforated metal tape for support or fastening of raceway is prohibited.
- Q. Where galvanized wire is used for cable supports above suspended ceilings, provide minimum #12 support wire independent of ceiling system secured at both ends. Paint or provide tag to distinguish supports from ceiling system.
- R. Welding directly on raceways, fittings, or outlet boxes is prohibited.

### 3.5 INSTALLATION OF VIBRATION ISOLATION PADS

- A. Select vibration device load ratings to match equipment loading and deflection criteria.
- B. Arrange pads in single or multiple layers of sufficient stiffness for uniform loading.
- C. Install pre-cut segments in accordance with manufacturer's written instructions to match shape of equipment base.

### 3.6 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

### 3.7 CONCRETE EQUIPMENT BASES

- A. Housekeeping Pads: Construct concrete housekeeping pads a minimum of 4-inches thick and 6-inches larger in both directions than supported unit.
- B. Exterior Equipment Pads: Construct exterior equipment pads a minimum of 8-inches thick and 6-inches larger in both directions than supported unit unless noted otherwise.
- C. Use 4000-psi, 28-day compressive-strength concrete unless otherwise noted. Comply with Division 03 Section "Cast-in-Place Concrete" and ACI standards for subbase requirements, concrete materials, reinforcement, placement, and cover requirements.
  - 1. Reinforce pads with a minimum #4 rebar on 12-inch centers each way or equivalent welded wire fabric. Support reinforcement and tie together to prevent displacement during construction.
  - 2. For interior pads, provide #4 dowels at 24-inch centers each way (minimum of 4) to anchor to structural slab below. Embed dowels into slab a minimum of 3-inches.
  - 3. Provide rubbed finish for all surfaces.
  - 4. Provide 3/4-inch chamfer at all exposed edges.
  - 5. Provide Engineer approved repairs if pad surface is rough or shows signs of honeycomb.
  - 6. Provide crown for exterior pads with a slope of 1/8-inch per foot.
  - 7. Do not set heavy equipment on pad for at least 7 days after pour unless approved by Engineer.
- D. Anchor equipment to concrete base.
  - 1. Locate anchors to be a minimum of 10 bolt diameters from edge of the base.
  - 2. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 3. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 4. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

### 3.8 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Coordinate all required openings and provide sleeves and inserts prior to construction of wall and floor systems. Where openings are missed or incorrectly located, provide core-drilling and patching at no additional expense to owner.

- C. Install sleeves without compromising structural integrity of wall or floor.
- D. Sleeves for Conduits or Cable Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Unless sleeve seal systems are used, size pipe sleeves to provide a minimum 1/4-inch annular clear space between sleeve and raceway. Where conduit motion due to expansion and contraction will occur, provide sleeves a minimum of two conduit sizes larger than the nominal conduit diameter.
  - 3. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls.
    - a. For conduit penetrations, cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
    - b. For cable penetrations, extend sleeve a minimum of 2-inches beyond surface of wall and provide plastic insulated bushing.
  - 4. Install sleeves for floor penetrations. Extend sleeves installed in floors a minimum of 6-inches above finished floor level unless noted otherwise. Install sleeves during erection of floors.
  - 5. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction occurs around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction.
- E. Sleeves for Cables Penetrating Non-Fire-Rated Gypsum Board Assemblies:
  - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 2. Seal space outside of sleeves with approved joint compound or acoustical sealant for gypsum board assemblies.
- F. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units and counter flashing applied in coordination with roofing work. Coordinate all work with roofing system to maintain roof warranty.
- G. Exterior-Wall and Floor Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seal system. Size sleeves to allow for manufacturer recommended annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Where sleeves are installed in core drilled openings, grout sleeve into the opening.
- H. Where sleeves are installed exposed in finished spaces, provide metal escutcheon plates of size to match the sleeve.

I. Sleeve-Seal-System:

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

3.9 ELECTRICAL SYSTEM FIRESTOPPING INSTALLATION

- A. Install firestopping at all penetrations of fire-rated assemblies. Comply with requirements in Division 07 and as outlined below.
- B. Coordinate location and proper selection of firestop devices with fire rated assembly. Ensure cast-in place devices are installed before placement of concrete.
- C. Install firestop materials in accordance with UL Fire Resistance Directory and manufacturer's written instructions.
- D. Affix permanent label to each side of penetration immediately adjacent to firestopping to communicate to futures installers and code authorities the following:
  1. Fire-stop product/system used
  2. Installation Company
  3. Penetration Hour Rating
  4. Installation Date
- E. Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities.

3.10 PAINTING

- A. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260500



## SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Building wire and cable rated 600 V and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.
  - 3. Control Voltage Conductors and Cables.
- B. Related Requirements:
  - 1. Refer to Division 27 for requirements related to balanced unshielded twisted pair (UTP) cabling.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. RoHS: Restriction of Hazardous Substances.
- B. Definitions
  - 1. Low Voltage: Circuits and equipment operating at more than 50VAC but less than 1000VAC for building electrical distribution systems.
  - 2. Control Voltage: Circuits and equipment operating at less than 50VAC for remote-control and signaling power-limited circuits.
  - 3. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
  - 4. Homerun: The run of raceway(s) and cable(s) between the panelboard or switchboard and the junction box in the area served where branch circuit cables originate.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. National Electrical Contractors Association (NECA)
    - a. NECA 104, "Installing Aluminum Building Wire and Cable"

- b. NECA/NACMA 120, "Standard for Installing Armored Cable (Type AC) and Type Metal-Clad (MC) Cable"

#### 1.4 SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

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

#### 2.2 BUILDING WIRE AND CABLE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Alpha Wire Company.
  - 2. Cerro Wire LLC.
  - 3. Encore Wire Corporation.
  - 4. General Cable Technologies Corporation.
  - 5. Okonite Company.
  - 6. Southwire Company.
- B. Building Wire Description: Flexible, insulated, and uninsulated, drawn current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- C. Cable Description: A factory assembly of one or more current-carrying insulated conductors in an overall protective sheath.
- D. General Requirements:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  - 2. RoHS compliant.
  - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- E. Copper Conductors: 98% conductive annealed copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

F. Conductor Insulation:

1. 600V, 90°C.
2. Comply with ANSI/NEMA WC 70/ICEA S-95-658.
3. THHN/THWN-2: Comply with UL 83.
4. XHHW-2: Comply with UL 44.
5. RHW-2: Comply with UL 44 and UL 2196.

2.3 SPLICING DEVICES & CONNECTORS

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

1. 3M; Electrical Products Division.
2. AFC Cable Systems, Inc.
3. Burndy
4. Gardner Bender.
5. Hubbell Power Systems, Inc.
6. Ideal Industries, Inc.
7. ILSCO.
8. NSi Industries LLC.
9. O-Z/Gedney;
10. Thomas & Betts.
11. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Material: Tin plated copper

D. Twist-On Wire Connectors: spring pressure type, 600V, 105°C insulation, capable of connecting two or more wires up to #8 AWG in a pigtail application.

E. Crimp Sleeve Splices: butt or parallel crimp type, copper sleeve with nylon cover and skirted insulators, capable of permanent connection of two or more wires up to #10 AWG.

F. Compression Splices: standard or long barrel type, 90°C, with cold shrink tubing, for use with hydraulic crimping tool, capable of permanent connection of wires #6 AWG and larger.

G. Ring or Flanged Fork Tongue Terminals: crimp type, 600V, 105°C insulation, insulated serrated barrel, capable of terminating wires up to #10 AWG.

H. No aluminum splicing devices or connectors are permitted.

2.4 CONTROL VOLTAGE CONDUCTORS AND CABLE

A. Control Cable: NFPA 70, Type CMG or CMP

1. Single or Multi-pair, twisted, minimum No. 18 AWG, stranded tinned copper conductors.
2. PVC insulation.
3. Shielded or Unshielded.
4. Flame Resistance:
  - a. CMG: Comply with UL1685.
  - b. CMP: Comply with NFPA 262.

B. Class 1, 2, and 3 Control Circuits: Stranded Copper, Type THHN/THWN-2

### PART 3 - EXECUTION

#### 3.1 CONDUCTOR AND INSULATION APPLICATION

- A. Feeders and Branch Circuits: Copper. THHN/THWN-2. Solid for #10 AWG and smaller; stranded for # 8 AWG and larger.
1. Provide XHHW-2 insulation for the following:
    - a. Circuits routed exposed on rooftops.
    - b. Conductors on the load side of a Variable Frequency Drive.
  2. Provide RHW-2 fire resistive cable in raceway for emergency system feeders located above ceilings and not protected by an automatic fire suppression system.
- B. Conductors for motors or vibrating or oscillating equipment: Extra flexible stranded.
- C. Cord Drops and Portable Appliance Connections: Type SOOW, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- D. Conductor sizes indicated on drawings are based upon 75 degree C rating unless noted otherwise.
- E. Minimum branch circuit or feeder size:
1. Not less than #12 AWG copper wire unless noted otherwise.
- F. Minimum control circuit conductor sizes:
1. Class 1 remote-control and signal circuits; No 14 AWG.
  2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
  3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG
- G. Provide all wire for the project in new and undamaged condition. Deliver in standard coils or reels. Wires and cables manufactured more than 24 months prior to date of delivery to the site are not acceptable.

#### 3.2 EXAMINATION

- A. Prior to installing conductors and cables:
1. Verify that raceway installation is complete according to Section 260533 "Raceways and Boxes for Electrical Systems" and ready for installation of conductors and cables.
  2. Verify that raceways are properly sized in accordance with NEC.

3. Visually inspect exposed raceways to ensure that raceways are not damaged and bends are not deformed.
4. Verify that raceways do not exceed the maximum number of bends between pull-points.
5. Verify raceways have been cleaned of all dirt and debris.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

#### A. Pulling Conductors in Raceways

1. Pull cables in accordance with cable manufacturer and pulling equipment manufacturer recommendations as well as applicable sections of the National Electric Code.
2. Use installation equipment, tools, and materials as necessary, such as sheaves, pulling eyes, basket grips, winches, cable reels and/or cable reel jacks, duct entrance funnels, and pulling tension gauges, and approved pulling lubricants where required to facilitate cable pulling without damage to cables or raceway.
3. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not use lubricants that harden or become adhesive with age. Apply lubricant where cables enter ducts and conduits and at all intermediate access points on long or difficult pulls.
4. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values. Utilize special remote readout equipment to ensure compliance.
5. Avoid abrasion and other damage to cables during installation. Provide physical protection of cables, such as using appropriately sized flexible cable guides or feed-in tubes, at the entrance of boxes and raceways.
6. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

#### B. Bend Radius

1. Handle conductors and cables carefully. Make bends in cables and conductors such that cables, conductors, sheaths, armor, etc., are not damaged.
2. Do not bend conductors and cables to less than the NEC and manufacturer recommended minimum bending radius.
3. Ensure that tools and accessories used to install conductors and cables, such as rollers, sheaves, trolley assemblies, tube guides, and/or raceways, are properly sized and utilized to be greater than the minimum bending radii of conductors and cables.
4. Minimize bending where conductors and cables enter or exit raceways, cabinets, and boxes. Do not install cables that have been bent or kinked to a radius less than the recommended dimension.
5. Install conductors only after insulating bushings are in place.

#### C. If multiple circuits are pulled in a single homerun, provide a dedicated neutral for each phase conductor. In these cases, a maximum of seven conductors (six current carrying and one ground) are permitted in a single conduit except for switch legs and travelers in multi-point switching arrangements. De-rate conductors per NEC.

#### D. Multi-wire branch circuits with a shared neutral are not permitted unless specifically noted on the drawings. Where indicated, group the phases and neutral together with cable ties in the panelboard and in all pull boxes.

- E. Install conductors for isolated power systems in as short a run of conduit as practicable. The use of pulling compound or lubricant is not permitted on conductors in isolated power systems.
- F. Voltage Drop:
  - 1. Adjust conductors and conduit sizes accordingly based on actual field installed conditions.
  - 2. Size and Install all feeders and branch circuits for a maximum 2% voltage drop in feeders and 3% in branch circuits with a maximum total voltage drop of 5%.
  - 3. Calculate using a load equal to 80% of the supply breaker rating unless the circuit breaker is rated to carry 100% of the load.
  - 4. Where the conductor length from the panel to the first outlet on a circuit exceeds the values below, adjust branch circuit conductors from the panel to the first outlet. Increase the conductor size of remaining branch circuit as needed to meet above voltage drop limitations.
    - a. For 277VAC homeruns exceeding 125-feet, #10 AWG minimum
    - b. For 120VAC homeruns exceeding 50-feet, #10 AWG minimum
    - c. For 120VAC homeruns exceeding 100-feet, #8 AWG minimum
- G. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- H. Install cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours.
- I. Bundle cables where run in groups using listed supports. Provide independent supports directly from structure, do not route through structure or on work of other trades.
- J. Metal Clad Cable, Type MC
  - 1. The use of metal clad cable is not permitted, except for connections to ceiling mounted recessed and semi-recessed luminaires concealed in accessible ceiling where the maximum length is limited to 72-inches.
- K. Control Circuit Conductors and Cables
  - 1. Use insulated spade lugs for wire and cable connection to screw terminals.
  - 2. Conductors installed within environmental air plenums shall be per NEC. Article 800 and other applicable codes, with FEP-type insulation or an approved equivalent. Provide plenum-rated cable supports where plastic straps or other supports, etc., are installed in plenum areas.
  - 3. Where indicated, systems and control conductors that are installed exposed shall not be routed across ceilings or ductwork. Provide independent supports anchored to building structure or other permanent support members.
  - 4. Install in such a manner as to not interfere with the access to or operation of equipment or removal of ceiling tiles.
  - 5. Nylon tie-wraps shall be installed in such a manner so as to bundle conductors neatly, allowing runouts of single conductors or groups to drop down to equipment served.
  - 6. Install grommets where dropping out of trays or into panels or service columns.
  - 7. Install sleeves with bushings where penetrating partitions.
  - 8. Provide firestopping for penetrations of fire rated assemblies with approved materials.

### 3.4 SPLICES, TAPS, CONNECTIONS, AND TERMINATIONS

- A. Prepare cable in accordance with the conductor, cable, splice and termination component manufacturers' recommendations and instructions.
- B. Cut conductors and cables using tools and methods which ensure a square cut. Do not nick or damage conductors.
- C. Ensure conductor inserts fully into the connector or termination with the insulation fitting closely to the connector or termination.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, a calibrated torque tools shall be used to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.
- E. Splices and Taps
  - 1. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.
  - 2. Make splices and taps in junction boxes or other enclosure approved for the wiring method.
  - 3. For conductors #10 AWG and smaller conductors, use pressure crimp type connections.
  - 4. For conductors #8 AWG and larger, use a hydraulic compression type connection, with cold shrink tubing and tape to restore full insulation value of the wire being spliced.
- F. Connections and Terminations
  - 1. Ensure that conductor temperature and ampacity ratings are compatible with connectors, terminals, and equipment to which they are to be connected.
  - 2. Provide crimp-applied ring or flanged fork type terminals for motor and equipment terminals where such terminals are provided on motor and equipment leads or on all stranded wire terminations using #10 AWG or smaller conductors.
  - 3. Motor Connections shall use connection lugs with motor stub splice insulators.
- G. Wiring at Outlets: Install conductors at each outlet with at least 12 inches of slack.
- H. All cables and wiring, regardless of voltage, installed in manholes or cable vaults shall be routed in such a manner to provide a minimum of 10 feet of slack cable for future splicing. Install cables along walls by utilizing the longer route from entry to exit. If both routes are symmetrical, provide a loop of cable secured to wall. All cables shall be tied to insulated cable supports on wall-mounted racks, spaced a maximum of three feet apart.

### 3.5 PROTECTION

- A. Intentional or unintentional painting of exposed low-voltage and/or control-voltage cabling insulation is prohibited. Ensure that exposed cabling is adequately protected from direct

painting or overspray whether painting is required within the electrical specifications or required by other disciplines/trades.

- B. Review the project's painting requirements for all disciplines and provide protection as required.
- C. Where exposed cabling is being installed in exposed ceiling or wall spaces that are required to be painted, provide cabling in enclosed raceways or provide alternate options for cable colors to engineer for approval.

### 3.6 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
  - 1. Identify all conductors by means of labels placed on conductors in all junction boxes and at each terminal point with labels indicating source, circuit number or terminal number.
  - 2. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.
  - 3. Identify each control voltage conductor or cable on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.
- B. Provide conductors, in all sizes of cable, with continuous solid insulation color(s) from the manufacturer. Taped ends shall not be acceptable.
  - 1. Conductors shall be color coded as follows:
    - a. 120/208 Volt Conductors
      - 1) Phase A: Black
      - 2) Phase B: Red
      - 3) Phase C: Blue
      - 4) Neutral: White
      - 5) Ground: Green
      - 6) Isolated Ground: Green/Yellow
    - b. 277/480 Volt Conductors
      - 1) Phase A: Brown
      - 2) Phase B: Orange
      - 3) Phase C: Yellow
      - 4) Neutral: Gray or White with Brown tracer
      - 5) Ground: Green
      - 6) Isolated Ground: Green/Yellow
  - 2. Control voltage wiring color coding shall be consistent throughout the project and shall match existing equipment and standards where applicable. Color coding for each system shall be unique.
  - 3. Conductors within enclosures that may be energized when enclosure disconnect is off - yellow or taped with 1/2" yellow tape every 6" of length, inside enclosure. Provide lamacoid plate warning sign on front of enclosure where this condition occurs.
  - 4. DC Wiring:
    - a. Positive: Light Blue
    - b. Negative: Dark Blue



### 3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Visual Inspections:
  - 1. Compare cable data with drawings and specifications.
  - 2. Inspect exposed sections of cable for physical damage and correct connections in accordance with drawings.
  - 3. Inspect bolted electrical connections for high resistance. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
  - 4. Inspect compression-applied connectors for correct cable match and indentation.
  - 5. Inspect for correct identification and arrangements.
  - 6. Inspect cable jacket insulation and condition.
- C. Electrical Tests:
  - 1. Perform insulation resistance testing for all electrical distribution system feeders unless notes otherwise. Testing may be witnessed by the Engineer and/or Commissioning agent. Schedule all tests with Architect with sufficient notice.
  - 2. Insulation resistance tests shall be performed at a DC voltage of 1,000 volts for 600 volt rated equipment, and at a DC voltage of 500 volts for 120-300 volt rated equipment. Test duration shall be one minute. Minimum acceptable (temperature corrected) resistance is 25 megaohms for 120-300 volt rated equipment and 100 megaohms for 600 volt rated equipment and wiring.
  - 3. Test instruments shall be calibrated to national standards within the last 12 months.
- D. Test and Inspection Reports: Prepare a written report to record the following:
  - 1. Test procedures used.
  - 2. Results that comply with requirements.
  - 3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- E. Cables will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.
- F. Submit test results to Architect and Engineer for approval

END OF SECTION 260519

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## SECTION 260526

### GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

#### PART 1 - GENERAL

##### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

##### 1.2 SUMMARY

- A. Description: Grounding and Bonding for electrical systems covers several different but interrelated systems including Electrical System Grounding, Equipment Grounding System, Grounding Electrode System, and interfaces with telecommunications bonding infrastructure as well as lighting protection systems.
- B. Section includes requirements for electrical system and equipment grounding, plus the following special applications:
  - 1. Underground distribution grounding.
  - 2. Grounding electrodes.
  - 3. Ground bonding common with lightning protection system.
- C. Related Requirements:
  - 1. Refer to Section 270526 "Grounding and Bonding for Communications Systems" for requirements associated with the telecommunications bonding infrastructure.

##### 1.3 REFERENCES

- A. Abbreviations
  - 1. MGB: Main Grounding Busbar
- B. Definitions
  - 1. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.
  - 2. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. National Electrical Contractors Association (NECA)

- a. NECA 331 – Standard for Building and Service Entrance Grounding and Bonding

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Coordination Drawings: Plans showing dimensioned locations of grounding electrodes, test wells, and other grounding features.
- C. Field quality-control reports. Provide test reports for each test specified in the field quality control section. Include copies of current equipment calibration certification.
- D. Closeout Submittal:
  - 1. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
  - 2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Instructions for periodic testing and inspection of grounding systems and features based on NETA MTS and NFPA 70B.
      - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
      - 2) Include recommended testing intervals.
  - 3. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
    - a. Test wells.
    - b. Grounding electrodes and connections.
    - c. Grounding arrangements and connections for separately derived systems.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

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

#### 2.2 MANUFACTURERS:

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB Blackburn
  - 2. Eaton B-Line
  - 3. Harger

4. Hubbell Burndy
5. Ilsco
6. nVent Erico
7. Panduit
8. VFC Lyncole

## 2.3 CONDUCTORS

- A. Insulated Copper Conductors: Comply with Section 260519 “Low-Voltage Electrical Power Conductors and Cables”.
- B. Bare Copper Conductors:
  1. Solid Conductors: ASTM B 3.
  2. Stranded Conductors: ASTM B 8.
  3. Tinned Conductors: ASTM B 33.
- C. Straps/Jumpers: Copper tape, braided conductors pre-terminated with copper ferrules, cross-sectional area no less than a No. 6 AWG conductor.

## 2.4 ELECTRICAL SYSTEM BUSBARS

- A. Grounding Busbar: Predrilled rectangular bars of annealed copper, minimum 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Size busbar length to accommodate initial conductor installation plus a 50% growth factor. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 1000 V and shall be Lexan or PVC, impulse tested at 5000 V.

## 2.5 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits consisting of graphite molds, copper oxide and aluminum weld metal, and electronic ignition system. Provide types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Irreversible Compression Connectors: Tin-plated copper, for installation using a hydraulic compression tool and die matched to connector type. Provide with die code or other visual indicator to ensure proper connector selection and uniform compression for a permanent connection.
  1. Taps: C-type, H-type, or Figure 6/8 type.
  2. Splices: Long Barrel straight or tee.
  3. Terminals: Two-hole lug long barrel type.
- D. Mechanical Connectors: Tin-plated high strength copper alloy or high strength cast bronze
  1. Water Service Pipe Clamps: Heavy-Duty, two-piece saddle type with stainless steel bolts.

2. Pipe Clamps: Heavy-Duty, U-bolt type with silicon bronze hardware.
3. Lay-in Lug Connector: Heavy-Duty, open face lug with hex head set screw.

## 2.6 GROUNDING ELECTRODES

- A. Ground Rods: 10 mil pure electrolytic copper coating with molecular bond to high strength steel core; 3/4 inch by 10 feet with chamfered end. Ensure ground rods are die-stamped near the top with the name and trademark of the manufacturer and the length in feet.
- B. Chemical-Enhanced Grounding Electrodes: Self-contained, maintenance free system consisting of a 10-foot copper tube with drilled holes, straight or L-shaped, charged with nonhazardous electrolytic chemical salts. Basis of Design: Lyncole XIT.
  1. Termination: Factory-attached No. 4/0 AWG copper conductor at least 48 inches long.
  2. Backfill Material: Electrode manufacturer's recommended enhancement material.
- C. Enhanced Composite Backfill: Electrically conductive, environmentally safe, maintenance free backfill material with neutral PH properties that creates a stable, non-corrosive, low resistance connection between a grounding electrode and earth. Basis of Design: Erico Ground Enhancement Material (GEM).
- D. Test Well: Lightweight polymer concrete, Tier 15 rated, non-slip cover, suitable for non-deliberate incidental traffic. 12-inch by 12-inch minimum, 12-inches deep unless noted otherwise, with "GROUND" legend unless noted otherwise.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Bond grounding bus and all non-current carrying metallic parts of raceways systems and equipment to common ground in accordance with the National Electrical Code, NECA 331, as shown on the Contract Drawings, and in accordance with the requirements of the local authority having jurisdiction.
- B. The size of the grounding and bonding conductors shall be not less than that given in Article No. 250 of the National Electrical Code, and/or as shown on the Contract Drawings.
- C. Interconnect all grounding systems in or on the structure to provide a common ground potential.
- D. Bond all outlet, junction, pull boxes, and enclosures to the equipment grounding conductor with a grounding pigtail.

### 3.2 APPLICATIONS

- A. Conductors: Install solid conductor for #10 AWG and smaller, and stranded conductors for #8 AWG and larger unless otherwise indicated.

1. Install bare conductors where not specifically identified as bare or insulated except where installed in conduit with associated phase conductors. Install insulated conductors in conduit with insulation of the same material as the associated phase conductors with which it is installed.
  2. Provide insulated conductors not exceeding No. 8 AWG in size with green colored insulation. Identify conductors larger than No. 6 AWG with 4-inch green tape at each termination and at all junction and pull boxes.
- B. Underground Grounding Electrode Conductors: Install bare copper conductor, sized per NEC or as indicated on drawings, whichever is larger.
1. Bury at least 24 inches below grade or below the frost line depth, whichever is greater.
  2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Electrical System Grounding Busbar: Install in electrical rooms housing service equipment, and elsewhere as indicated to provide a common connection point for individual grounding electrode conductors and bonding jumpers.
1. Install bus horizontally, on insulated spacers 4 inches minimum from wall, 18 inches above finished floor unless otherwise indicated.
  2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
  3. Provide green laminated plastic nameplate with 1/2" high white letters indicating function of ground bus (i.e. "Service Main Ground Busbar").
- D. Conductor Terminations and Connections:
1. Pipe and Equipment Grounding Conductor Connections: Mechanical connectors.
  2. Underground and Exposed Exterior Connections: Exothermic welded connectors except at test wells and as otherwise indicated.
  3. Connections to Ground Rods at Test Wells: Mechanical connectors.
  4. Connections to Structural Steel: Exothermic welded connectors.
  5. Connections to Busbars: Irreversible compression connectors.

### 3.3 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the neutral bus except where service equipment neutral and ground bussing complies with exceptions listed in the NEC. Install a main bonding jumper between the neutral bus and ground bus. Provide external grounding busbar and install grounding electrode conductor to interconnect main grounding busbar and neutral bus.
- B. Where ground fault protection is installed, ensure interconnection of neutral bus and ground bus does not interfere with correct operation of fault protection.

### 3.4 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Transformers: Provide grounding in accordance with the NEC and the following:

1. System Bonding Jumper (SBJ): Install at the source enclosure between the grounded terminal (neutral) and the equipment grounding terminal.
2. Supply Side Bonding Jumper (SSBJ): Install wire type SSBJ to bond the source enclosure to the enclosure at the first disconnect or overcurrent protective device.
3. Grounding Electrode Conductor (GEC): Install at the source enclosure from the SBJ connection point to the building grounding electrode system.
4. Bonding Jumpers: Where the metal water piping and/or the metal structural steel building frame in the area served by the separately derived system are not used as a grounding electrode, provide bonding jumper to the GEC connection point at the source enclosure.
5. Equipment Grounding Conductor (EGC): Bond the EGC of the primary feeder to the equipment grounding terminal.

### 3.5 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements for utility equipment.
- B. Exterior Pad-Mounted Equipment: Install a minimum of two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with equipment by connecting them to underground grounding conductors and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

### 3.6 EQUIPMENT GROUNDING AND BONDING

- A. Equipment Grounding Conductors: Install insulated equipment grounding conductors with all feeders and branch circuits. Provide conductors of the same wire/cable type as the ungrounded current carrying conductors.
- B. Increase equipment grounding conductor sizes in accordance with NEC article 250 where ungrounded current carrying conductor sizes are increased to minimize voltage drop.
- C. Provide all circuits with a dedicated equipment grounding conductor unless noted otherwise.
- D. Provide an equipment grounding conductor to each outlet on circuits protected by a GFCI circuit breaker.
- E. At all metallic outlet, junction and pull boxes, bond the equipment grounding conductor to the enclosure.
- F. Metal Poles Supporting Outdoor Lighting Fixtures: Install a ground rod and a separate insulated equipment grounding conductor at each pole in addition to grounding conductor installed with branch-circuit conductors.

### 3.7 INSTALLATION

- A. Grounding Electrode Conductors and Bonding Jumpers: Securely fasten and route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid



obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

1. Route conductors to maintain a downward or horizontal direction to ground with a minimum bend radius of 8-inches.
  2. Protection: Install above grade conductors No 6 AWG or larger exposed to physical damage and all conductors smaller than No. 6 AWG in schedule 80 PVC conduit. Where metallic conduit is required, bond each conduit end to the electrode or ground conductor as close to the openings as possible with a full-size conductor and bonding bushing to create an electrically parallel path.
  3. Clearance: Maintain a minimum separation of 12-inches from open telecommunications cable groups.
- B. Bonding for Lightning Protection Systems: Where lightning protection systems are installed comply with NFPA70, NFPA 780, and UL 96 for bonding the lightning protection system grounding electrodes with the building grounding electrode system.
1. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor.
  2. Do not use conductors and electrodes for grounding the lightning protection system in place of the grounding electrodes required by this specification and section 250.50 of NFPA 70.
- C. Ground Rods: Auger 6 inch diameter hole to depth 6 inches shorter than the ground rod length. Drive rods a minimum of 12 inches into the bottom of the hole until tops are 12 inches below final grade. After installing connections, backfill around ground rod with enhanced composite backfill.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
  2. Except at test wells, use exothermic welds for all below-grade connections to ground rods.
  3. For grounding electrode system at the service, install at least three rods spaced at least two-rod lengths from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole.
1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Chemical Enhanced Grounding Electrodes: Install in accordance with electrode manufacturer's recommendations. Install test well at each chemical enhanced grounding electrode.
- F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts. Install straps and jumpers such that it does not restrict movement of the structure to which it is connected.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

G. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes using a mechanical connector. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Other Metal Piping: Bond each aboveground portion of metal piping systems, including gas piping, downstream from its equipment shutoff valve in an accessible location.
4. Except for water piping, do not utilize piping systems as a ground path where dielectric fittings are utilized. Do not use bonding jumpers to bridge over such fittings.
5. Do not use underground portions of natural gas, flammable gas, or liquid fuel piping as grounding electrodes.

H. Grounding for Steel Building Structure:

1. Where the building's steel frame is made discontinuous by masonry breaks or expansion joints, provide an accessible No. 500 kcmil bare copper jumper with exothermic weld connections to bond steel sections together, making the steel frame electrically continuous. The installation of the bonding jumpers shall be reviewed by the Engineer before covering.

I. Concrete-Encased Grounding Electrode (Ufer Ground): Provide and fabricate in accordance with NFPA 70; use a minimum of 20 feet bare copper conductor no smaller than #4 AWG located in building footing that has direct contact with earth.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts using exothermic weld connections. Extend grounding conductor below grade and connect to building's ground ring or to grounding electrode external to concrete.

J. Exothermic Welded Connections: Provide in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

1. An electronic ignition system shall be used and weld metal shall be a self-contained, sealed system with a bi-metallic fuse to start the reaction.
2. Comply with AWS Standards and manufacturer's instructions for procedures, appearance, and quality of welds; and methods used in correcting welding work.
3. Ensure process joins all strands and does not cause the parts to be damaged or weakened.
4. Completed connection or joint must be equal or larger in size than the conductors joined and have the same current-carrying capacity as the largest conductor.

- K. Mechanical Connections: Install mechanical connections in accessible locations.
  - 1. Tighten connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values.
  - 2. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
- L. Connections between Dissimilar Metals: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
  - 1. Clean surfaces and apply antioxidant compound prior to installation of connections.
  - 2. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
  - 3. Make connections with clean, bare metal at points of contact.
  - 4. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
  - 5. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
  - 6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

### 3.8 FIELD QUALITY CONTROL

- A. Buried or concealed grounding electrode systems shall be accepted by Engineer and Owner Representative before backfilling or covering.
- B. Tests and Inspections:
  - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  - 2. Bond Resistance Test: Test the bonding connections of the system using a certified micro-ohmmeter, taking two-point resistance measurements across each bond in the grounding electrode system. The maximum acceptable value of each bond is 0.5 milliohms.
  - 3. After completing installation of the grounding electrode system and finished grade, but before permanent electrical circuits have been energized, test for compliance with requirements.
  - 4. Grounding Electrode Resistance Test: Test completed grounding electrode system at service disconnect enclosure grounding terminal and at ground test wells using a manufacturer calibrated and certified 3-point ground resistance tester.
    - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    - b. Perform tests by three-point fall-of-potential method according to IEEE 81.

- c. Disconnect and isolate the grounding electrode conductor from the electrical system at the main ground bus before testing.
  - d. Install outer test probe outside the sphere of influence of the grounding electrode system. This value is typically 10 times the size of the grounding electrode system, between 300 and 500 feet from the main ground bus.
  - e. Install inner test probe at 10 equally spaced intervals, in a straight line between the grounding electrode system connection and the outer test probe and note the resistance reading at each location.
  - f. The resistance measurements taken from the flat part of the curve shall be averaged to determine the grounding electrode system resistance to earth.
  - g. If large variations are noted in the resistance measurements, the outer test probe should be relocated further from grounding electrode system (outside its sphere of influence) to achieve some degree of flatness on the resistance curve.
  - h. Excessive Ground Resistance: If resistance to ground exceeds 5-ohms, notify Engineer promptly and include recommendations to reduce ground resistance. If deemed necessary by the Engineer, additional electrodes shall be placed and the measurement process repeated until the desired ground potential achieved.
5. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include test probe locations, observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare detailed test and inspection reports and submit to Engineer for review.

END OF SECTION 260526

## SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 – General Requirements for Electrical Systems apply to this Section.

#### 1.2 SUMMARY

- A. This section is intended to specify the raceways, fittings, boxes, cabinets, specialties and related items necessary to complete the work as shown on the drawings and specified herein.
- B. Section Includes:
  - 1. Metal conduits and fittings
  - 2. Nonmetallic conduits and fittings
  - 3. Surface metal raceway
  - 4. Metal wireways and auxiliary gutters.
  - 5. Boxes, enclosures, and cabinets
  - 6. Wall ducts and trench ducts.
- C. Related Requirements:
  - 1. Refer to Division 07 firestopping section and Section 260010 “General Requirements for Electrical Systems” for penetration firestopping requirements related to electrical pathways and boxes.
  - 2. Refer to Section 270528 “Pathways for Communications Systems” for supplemental pathway requirements related to communications systems.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. EMT: Electrical Metallic Tubing
  - 2. FMC: Flexible Metal Conduit
  - 3. GRC: Galvanized Rigid Steel Conduit
  - 4. IMC: Intermediate Metal Conduit
  - 5. LFMC: Liquid-tight Flexible Metal Conduit.
  - 6. RAC: Rigid Aluminum Conduit
  - 7. RMC: Rigid Metal Conduit
- B. Definitions
  - 1. Outlet: A point on the wiring system at which current is taken to supply utilization equipment.

2. Raceway: an enclosed channel designed for enclosing and protecting electrical, communications, and signaling wires and cables.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
1. National Electrical Contractors Association (NECA)
    - a. NECA 101 - Standard for Installing Steel Conduits (RMC, IMC, EMT)
    - b. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC)
  2. National Electrical Manufacturers Association (NEMA)
    - a. NEMA FB 2.10 - Selection and Installation Guidelines for Fittings for Use with Non-Flexible Metallic Conduit or Tubing (Rigid Metal Conduit, Intermediate Metal Conduit, and Electrical Metallic Tubing)
    - b. NEMA FB 2.20 - Selection and Installation Guidelines for Fittings for Use with Flexible Electrical Conduit and Cable
    - c. NEMA RV 3 - Application and Installation Guidelines for Flexible and Liquid-tight Flexible Metal Conduits

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop drawings: For custom enclosures, cabinets, or boxes.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

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

#### 2.2 METAL CONDUIT AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  1. AFC Cable Systems, Inc.
  2. Allied Tube & Conduit.
  3. Anamet Electrical, Inc.
  4. Calconduit
  5. Electri-Flex Company.
  6. Nucor Tubular Products.
  7. O-Z/Gedney.

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8. Picoma Industries.
  9. Robroy Industries.
  10. Southwire Company.
  11. Thomas & Betts Corporation.
  12. Western Tube and Conduit Corporation.
  13. Wheatland Tube Company.
- B. Electrical Metallic Tubing (EMT) and Elbows:
1. Comply with ANSI C80.3 and UL 797.
- C. Galvanized Rigid Steel Conduit (GRC, RMC) and Elbows:
1. Comply with ANSI C80.1 and UL 6.
  2. Zinc coating both inside and outside by means of hot-dip galvanizing.
  3. Use only threaded fittings for GRC.
- D. PVC Coated Galvanized Rigid Steel Conduit (GRC) and Elbows:
1. Comply with NEMA RN 1
  2. Minimum 40 mil thick PVC exterior coating with overlapping sleeves protecting threaded joints.
  3. Minimum 2 mil thick urethane interior coating.
  4. Clear urethane coating over hot-dip galvanized threads.
- E. Intermediate Metal Conduit (IMC) and Elbows:
1. Comply with ANSI C80.6 and UL 1242
- F. Flexible Metal Conduit (FMC):
1. Comply with UL 1.
  2. Continuous interlocked hot-dip zinc galvanized steel with smooth interior and exterior.
  3. Suitable for dry locations.
- G. Liquid-tight Flexible Metal Conduit (LFMC):
1. Comply with UL 360.
  2. Continuous interlocked hot-dip zinc galvanized steel core with smooth interior and exterior.
  3. Suitable for wet and dry locations, direct burial applications, and concrete encasement.
  4. Sunlight resistant, flame retardant thermoplastic PVC jacket resistant to heat, oil, and chemical breakdown.
- H. Metal Fittings
1. Comply with NEMA FB1 and UL 514B.
  2. Listed and labelled for type of conduit, location, and use.
  3. Fittings for EMT:
    - a. Compression type, zinc-plated galvanized steel.
    - b. Concrete-tight- or rain-tight, hardened steel locknuts, and nylon insulating throats.
  4. Fittings for GRC and IMC:
    - a. Threaded zinc plated steel.
    - b. Concrete-tight- or rain-tight, nylon insulating throats.

5. Conduit Bodies:
    - a. Material: gray iron or heavy copper-free cast aluminum
    - b. Available in varying configurations with integral bushing and gasketed coverplate.
  6. Expansion/Deflection Fittings: UL 651 listed, manufactured coupling accommodating 3/4-inch linear movement from normal and 30-degree angular movement in all directions
    - a. Basis of Design: OZ/Gedney DX
    - b. PVC or steel sleeve to match conduit type with neoprene jacket, rated for environmental conditions where installed.
    - c. Integral braided copper bonding jumper.
  7. Fittings for FMC and LFMC:
    - a. LFMC: Tubular Steel, zinc-plated with gland nut, sealing ring, high tensile grounding ferrule, insulated throat, and body for liquid tight connection.
  8. Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
  9. "Kwik-Couple" type fittings are not permitted.
  10. Indentation, set-screw, or die-cast fittings are not permitted.
- I. Joint Compound for threaded conduit: UL 2419 listed for use in conduit assemblies and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## 2.3 NON-METALLIC CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Allied Tube & Conduit
  2. Cantex
  3. Carlon
  4. Heritage Plastics
  5. National Pipe & Plastics
  6. Prime Conduit
- B. Rigid Polyvinylchloride (PVC) Conduit:
1. Comply with NEMA TC-2 and UL 651.
  2. Sunlight resistant and suitable for use with 90 degree C conductors.
  3. Type EPC-40 suitable for normal duty applications.
  4. Type EPC-80 suitable for heavy duty applications.
- C. Non-Metallic Fittings
1. Comply with NEMA TC 3 and UL514B.
  2. Listed and labelled for type of conduit, location, and use.
  3. Compatible with conduit type and material.
  4. Solvents and Adhesives: as recommended by conduit manufacturer.



## 2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Eaton B-Line
  - 2. Hubbell Wiegmann.
  - 3. nVent Hoffman.
  - 4. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise required by environmental application, and sized according to NFPA 70. Minimum of 14-gauge steel before finishes are applied.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.
  - 1. Provide knockouts on all runs, unless otherwise indicated or prohibited by codes.
  - 2. Provide dividers to separate conductors of different insulation levels or where required by equipment vendor installation instructions.
- D. Wireway Covers: Furnish with continuous hinged covers on all runs and removable covers on all fittings unless otherwise noted, to allow a continuous unobstructed path for conductor installation.
- E. Finish: Manufacturer's standard enamel finish resistant to corrosion, moisture, and oil.
- F. Size: available in nominal sizes 2-1/2-inch by 2-1/2-inch, 4-inch by 4-inch, 6-inch by 6-inch or 12-inch by 12-inch.
- G. Install supports to allow unobstructed access to wireway interior. Use minimum 1/4-inch rod hangers for up to 4-inch by 4-inch wireway, 3/8-inch rod up to 8-inch by 8-inch wireway, and 1/2-inch rod for 12-inch by 12-inch wireway.

## 2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Eaton Crouse-Hinds.
  - 2. Emerson/Appleton Electric.
  - 3. FSR Inc.
  - 4. Garvin Industries
  - 5. Hoffman.
  - 6. Hubbell Killark.
  - 7. Milbank Manufacturing Co.
  - 8. Mono-Systems, Inc.
  - 9. O-Z/Gedney.
  - 10. RACO / Hubbell.

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11. Stahlin Non-Metallic Enclosures.
  12. Thomas & Betts.
  13. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets shall be listed for intended use.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.
- E. Luminaire Outlet Boxes: Non-adjustable, designed for attachment of luminaires, listed and marked for the maximum allowable weight with at least a 2.0 safety factor for the anticipated fixture weight.
- F. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1, constructed of code gauge, galvanized steel with sides formed and corner seams riveted or welded before galvanizing
- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- I. For box extensions and mud rings used to accommodate building finishes, provide with same material as recessed box.
- J. Minimum Device Box Dimensions unless noted otherwise:
1. Single gang: 4-inches square by 2-1/8-inches deep with single gang extension ring.
  2. Two gang: 4-inches square by 2-1/8-inches deep with two-gang extension ring.
  3. Three gang: 8-5/8-inches by 4-1/2-inches by 2-1/2-inches deep with three gang extension ring.
  4. Four gang: 10-7/16-inches by 4-1/2-inches by 2-1/2-inches deep with four gang extension ring.
- K. Gangable boxes are prohibited.
- L. Boxes assembled with sheet metal screws are prohibited.
- M. Hinged Cover Enclosures: Comply with UL 50 and NEMA 250, suitable for installed environment with continuous-hinge cover and flush latch unless noted otherwise.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  2. Nonmetallic Enclosures: Fiberglass
  3. Interior Panels: Steel, all sides finished with manufacturer's standard enamel.

## PART 3 - EXECUTION

### 3.1 RACEWAY APPLICATION

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of raceways. Consult Architect for resolution of conflicting requirements.
- B. Apply raceway products as specified below unless otherwise indicated:
  - 1. Refer to Section 260543, "Underground Ducts and Raceways for Electrical Systems" for additional requirements related to raceways installed underground outside of the building footprint.
  - 2. Exterior and Exposed: GRC
  - 3. Concealed Underslab: GRC or PVC Type EPC-40 where approved.
  - 4. Interior, Concealed in Ceilings, Walls, and Partitions: EMT, IMC, or GRC
  - 5. Interior, Concealed in Concrete or Grouted Masonry Walls and Partitions below grade: IMC or GRC
  - 6. Interior, Damp or Wet Locations: GRC
  - 7. Interior, Where exposed and Not Subject to Physical Damage: EMT, GRC, or IMC. Raceway locations include the following:
    - a. Electrical Rooms
  - 8. Interior, Where Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
    - a. Loading dock.
    - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    - c. Mechanical rooms (below 8'-0").
    - d. Gymnasiums.
  - 9. Interior, where Exposed in washdown area and Subject to Severe Physical Damage: PVC Coated GRC. Raceway locations include the following:
    - a. Exposed stub-ups in Commercial/Institutional Kitchen or Cafeteria.
  - 10. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 11. Connection to ceiling mounted recessed and semi-recessed luminaires and electrical devices: FMC.
  - 12. Boxes and Enclosures: NEMA 250, Type 1 except as follows:
    - a. Damp or Wet locations: NEMA 250, Type 3R
    - b. Commercial/Institutional Kitchens and Cafeterias: NEMA 250, Type 3R
    - c. Corrosive environments: NEMA 250, Type 4X
  - 13. Exposed Boxes subject to physical damage: Die cast metal boxes with threaded hubs.
  - 14. EMT is not permitted underslab, embedded in concrete slabs, or where exposed to physical damage.
  - 15. Non-metallic conduit is not permitted for the following applications unless approved by the Engineer:
    - a. Interior Locations including environmental air plenums.
    - b. Applications where a redundant ground fault path is required by code.
  - 16. Flexible non-metallic conduit is not permitted.
  - 17. Unless otherwise indicated on the drawings, intermediate metal conduit (IMC) may be used in any location in place of rigid galvanized steel conduit (GRC), where permitted by codes, and where approved by the Engineer.

- C. Minimum Raceway Size: 3/4-inch trade size unless noted otherwise on the drawings.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
  - 3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
  - 4. Flexible Conduit: Use only steel fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth or where prolonged contact with construction materials will degrade the aluminum.
- F. Install raceways and fittings in a manner to avoid use of dissimilar metals that would result in galvanic action corrosion.
- G. Install surface conduits or raceways only where indicated on Drawings.
- H. Do not install surface conduits or raceways on exterior facades unless approved by Engineer.
- I. Do not install nonmetallic conduit where ambient temperature or operating temperature of the conductors exceeds the rating of the raceway.
- J. Conduit installed embedded in concrete slabs is not permitted.

### 3.2 RACEWAY INSTALLATION

- A. Comply with requirements in Section 260500 "Common Work Results for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1, NECA 101, NECA 111 and manufacturer's written instruction for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with utility company requirements for raceways and boxes containing utility company conductors.
- E. Size raceways to conform with Annex C, of the National Electrical Code, unless otherwise shown on the Contract Drawings.
- F. Level and square raceway runs and install at proper elevations and required heights. Hold tight to structure wherever possible, to maximize available space and not restrict other trades.

- G. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated.
- H. Install conduits with runs parallel or perpendicular to building lines, walls, structural members or intersections of vertical planes and ceilings, with right angle turns consisting of cast metal fittings or symmetrical bends unless otherwise shown. Randomly routed conduits are not acceptable.
- I. Make bends in raceway using large-radius preformed elbows. Provide concentric bends for parallel runs of conduit. Conform with NFPA 70 minimum radii requirements for field bending. Use only equipment specifically designed for material and size involved.
- J. Install no more than the equivalent of three 90-degree bends in any conduit run. Support within 12-inches of changes in direction.
- K. Provide junction boxes or pull boxes so that conduit runs do not exceed 100 feet, or as shown on the Contract Drawings. Size junction boxes per NEC, Article 370.
- L. Provide conduit supports spaced not more than 8-feet apart.
- M. Support conduit within 12-inches of enclosures to which attached.
- N. Do not drill into bar joists to support raceways or cables.
- O. Install conduits at least 12-inches away from flues, steam, or hot water pipes.
- P. Conduit installed under concrete slabs is permitted for feeders and for branch circuits serving floor outlets. Underslab conduit is prohibited for other locations unless noted on the drawings or with permission of the engineer. Where approved, comply with the following:
  - 1. Locate raceway a minimum of 12-inches below the bottom of slab.
  - 2. Provide minimum 2-inch spacing between conduits to ensure proper compaction of structural fill.
  - 3. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
  - 4. Transition underslab RNC to GRC for all bends larger than 20-degrees and for all stub-ups through a slab on grade. Arrange stub-ups so curved portions of bends are not visible above finished slab. Extend GRC stub-ups a minimum of 6" above the concrete slab. Schedule 80 PVC stub-ups are allowed where approved by engineer.
  - 5. Seal around conduits when penetrating vapor barriers.
  - 6. Where installed in corrosive soils, coat all underslab rigid steel conduit with two coats of bitumastic paint such as "Asphaltum".
- Q. Where raceways are subject to environmental changes, locate seals immediately at the boundary so no fittings or boxes are between the seal and the change of environments that would allow migration of condensation within the raceway system. Seal the interior of all raceways at the following points:
  - 1. Where conduits pass from cold to warm locations, such as boundaries of refrigerated spaces and at building wall and roof penetrations.
  - 2. Where an underground service raceway enters a building or structure.
  - 3. Conduit extending from interior to exterior of building.

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4. Conduit extending into pressurized duct and equipment.
  5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
  6. Where otherwise required by NFPA 70.
- R. Install conduits in a manner to ensure against collection of trapped condensation. Arrange all runs of conduit to be devoid of traps. Provide trapped conduit runs with explosion proof drains at low points.
- S. At hazardous locations, install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed non-shrink sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish like that of adjacent plates or surfaces.
- T. Coordinate with other trades, including metal and concrete deck trades, as necessary to interface installation of electrical raceways and components.
- U. Complete installation of electrical raceways before starting installation of cables or wires within raceways.
- V. Take precautions to prevent the lodgment of dirt, plaster, or trash in all conduit or tubing, fittings and boxes during construction. Use mandrel to clean all conduit for floor boxes or conduit below grade and ensure its swabbed free of debris or moisture before wiring is installed.
- W. Unless using GRC, do not locate conduits, cables, raceways, and enclosures within 2 inches of bottom of metal-corrugated sheet roof decking, measured from the lowest surface of the roof decking to the top of the conduit, cable, raceway, or box.
- X. Conduits, cables, raceways, and enclosures are not permitted in concealed locations of metal-corrugated sheet decking type roofing.
- Y. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72-inches of flexible conduit for ceiling mounted recessed and semi-recessed luminaires, and 36-inches for all other equipment subject to vibration, noise transmission, or movement, and for transformers and motors.
1. Install as a single piece with clamp-on insulated throat connectors designed for the purpose.
  2. Provide strain relief fittings where subject to vibration.
  3. Provide an equipment grounding conductor and bonding jumper at all locations.
  4. For LFMC, provide a minimum of 18-inches and loop to avoid restraining vibrating equipment.
- Z. Stub-ups to Accessible Ceilings:
1. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or into an enclosure.
  2. Where conduits terminate at a cable tray pathway, provide listed fitting to secure conduit to cable tray.

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- AA. Mechanically fasten conduit terminations at a wireway, provide metal insulated bushings, and bond to the wireway with bonding jumper.
- BB. Furnish conduit bodies in proper configurations, avoiding excessive openings. Any openings that are left shall be properly plugged. Wiring splices within conduit bodies are not permitted.
- CC. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- DD. Provide a completely separate raceway system, including junction boxes and pull-boxes, for each emergency power, optional stand-by, and normal power system for complete separation in accordance with NEC.
- EE. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of secured slack at each end of pull wire. Secure pull string at each end and cap raceways.
- FF. Coordinate with vendors and provide extra pull-strings as required to ensure enough pull strings.
- GG. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
- HH. Raceway Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines
1. Install raceways square to enclosures and terminate with appropriate fitting:
  2. For enclosures without hubs, terminate with appropriate fitting, insulated throat liner, and case-hardened locknuts on both sides of enclosure wall.
  3. Terminate rigid conduits with threaded hubs or with locknuts on inside and outside of enclosure and insulated throat metal bushing.
  4. Install locknuts hand tight, plus one-quarter turn more.
  5. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
  6. All threaded fittings shall engage a minimum of seven full threads. Fasteners shall be properly torqued to manufacturer's recommendations.
  7. Split sleeve insulators are not permitted.
- II. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- JJ. Expansion-Joint Fittings:
1. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
  2. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

- KK. Where raceways penetrate rooms or walls with acoustical requirements, seal raceway openings on both sides of penetration with acoustically rated putty or sealant.

### 3.3 BOX AND ENCLOSURE INSTALLATION

- A. Provide electrical outlets and enclosures as required for splices, taps, wire pulling, and equipment connections.
- B. Provide pull boxes as required to maintain conduit run and bend limitations specified herein.
- C. Size all outlets, pull boxes, junction boxes, cabinets, etc., per adopted edition of the National Electrical Code.
- D. Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- E. Install interior and exterior outlet boxes recessed in building construction with face or cover flush with finished surfaces unless noted otherwise. Where outlet boxes are installed in walls of glazed tile, brick, concrete block, or in walls covered by wood wainscot or paneling, provide deep box to ensure the outlet boxes are installed straight and secure in walls.
- F. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements and architectural elevations. Install boxes with height measured to center of box unless otherwise indicated.
- G. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box. Do not split the mortar joint
- H. Provided 3/4-inch rigid conduit pendants where lighting fixtures, appliances, or wiring devices are to be suspended from ceiling outlet boxes. Outlet boxes shall be malleable iron, provided with self-aligning covers with swivel ball joint and #14-gauge steel locking ring. Provide safety chain between building structure and housing for all fixtures, appliances, or devices greater than 10 lbs weight. Install fixtures plumb and level. Cover pendants shall be finished to match fixtures.
- I. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- J. Locate boxes so that cover or plate does not span different building finishes.
- K. Provide spanner bars to support all boxes from more than one side by spanning two framing members.
- L. Fasten boxes up to 4-11/16 square size to their mounting surface or support with two fasteners of proper size. Fasten larger sizes with four fasteners, minimum.
- M. Support boxes recessed in ceilings independent of ceiling tiles and ceiling grid.



- N. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits or ceiling support wires.
- O. Provide all cabinets and boxes for NEMA 1 applications with knockouts, as necessary, or field cut with approved cutting tools which will provide a clean, symmetrically cut opening to maintain UL listing of enclosure.
- P. Replace any unused knockouts or openings with a listed knockout closure.
- Q. Coordinate with equipment vendors to provide special sized outlet boxes to support installed equipment.
- R. Where boxes and enclosures are located in areas or on walls with acoustical requirements, seal openings and knockouts in back and sides of boxes with acoustically rated putty or sealant and provide gasket for wall plates and covers.

### 3.4 GROUNDING AND BONDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems".
- B. Bond all metal boxes, junction boxes and pull boxes with pigtails to the equipment grounding conductor.
- C. Provide insulated throat grounding bushings with appropriately sized bonding jumpers for the following locations to maintain electrical continuity between the raceway and enclosure:
  - 1. Metal raceways and enclosures that contain service conductors.
  - 2. Metal raceways and enclosures that contain grounding electrode conductors.
  - 3. Where metal raceways containing circuits over 250V terminate in a concentric or eccentric knockout at cabinets, enclosures, or sheet metal pull boxes listed in accordance with UL 50.
  - 4. Where the integrity of a concentric or eccentric knockout has been compromised.
  - 5. Metal raceways and enclosures that contain feeders.

### 3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.
- B. Protect threads on conduits and fittings with plastic protectors or other means to prevent damage prior to installation.
- C. Provide protection for all conduit stubbed through floor during construction with plastic caps approved for this purpose.

3.6 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
- B. Identify all junction, outlet and pull boxes in data/mechanical/electrical rooms and above ceilings with panel and circuit designation on outside of covers. Identify all exposed junction, outlet and pull boxes in finished areas with panel and circuit designation on inside of covers.

3.7 PAINTING

- A. Raceways installed in exterior locations shall receive one coat of primer, two coats finish paint after preparation of galvanizing, color selected by Architect.
- B. Exposed raceways in painted interior areas shall be painted to match adjacent finishes.

END OF SECTION 260533

## SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Direct-buried and concrete-encased conduits, ducts, and duct accessories.
  - 2. Handholes and boxes.
  - 3. Utility Structure accessories.
- B. Related Requirements:
  - 1. Refer to Section 260533 “Raceways and Boxes for Electrical Systems” for pathway requirements installed under building slabs.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. GRC: Galvanized rigid conduit.
  - 2. IMC: Intermediate metal conduit.
  - 3. RNC: Rigid nonmetallic conduit.
- B. Definitions
  - 1. Backfill: Earth or other controlled material placed in trenches for filling and grading back to a finished state.
    - a. Initial Backfill (encasement): Backfill placed beside and over conduit arrangements in a trench, including haunches to support sides of conduits.
    - b. Final Backfill: Backfill placed over initial backfill to fill a trench.
  - 2. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying conduit.
  - 3. Duct: A single or multiple underground conduits encased in concrete or direct buried.
  - 4. Duct Bank: An arrangement of two or more ducts installed together.
  - 5. Encasement: Material placed around a duct or duct bank to provide additional protection.
  - 6. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

- 1. National Electrical Manufacturers Association (NEMA):
  - a. NEMA TCB-2 "Guidelines for the Selection and Installation of Underground Nonmetallic Raceways".

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product.
- B. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures along with dimensions from buildings or other benchmarks.
  - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
- C. Field quality-control reports including digital photographs of all concealed work.
- D. Closeout Submittals
  - 1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", ensure all utilities, structures, and underground conduits are surveyed and recorded on as-built drawings.

#### 1.5 FIELD CONDITIONS

- A. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with IEEE C2 and NFPA 70.

#### 2.2 CONDUITS AND FITTINGS

- A. Comply with 260533 "Raceways and Boxes for Electrical Systems".

## 2.3 DUCT ACCESSORIES

- A. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during encasement or backfilling.
- B. Fabric Innerduct: Continuous, nylon resin polyester, multi -pocket fabric innerduct, with internal pull tape. Maxcell or equal.
- C. Pull Line: Flat, woven, polyester or polyaramid tape, low stretch, pre-lubricated for reduced friction. Strength suitable for required pulling tensions with a minimum of 200-lb. Muletape or equal.
- D. Underground Detectable Warning Tape: Flexible tape constructed with solid aluminum foil backing and clear film laminate, 6-inches wide, 5-mil overall thickness.
  - 1. Suitable for the method of installation and locating underground utility lines.
  - 2. Chemically inert tape material and ink, resistant to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
  - 3. Comply with APWA Uniform Color Code.
  - 4. Inscriptions for Red-Colored Tapes: "CAUTION BURIED ELECTRIC LINE BELOW".
  - 5. Inscriptions for Orange-Colored Tapes: "CAUTION BURIED COMMUNICATIONS LINE BELOW".
- E. Duct Sealants: Re-enterable, two-part, closed-cell urethane foam capable of sealing conduits with multiple cable configurations.
  - 1. Capable of withstanding temperatures from -40 deg F to 200 deg F and holding 22 feet waterhead pressure continuous.
  - 2. Chemically resistant to gasoline, oils, dilute acids, and bases.
  - 3. Compatible with cable jacket and shall not affect the physical or electrical properties of wire and cable.
  - 4. Workable at temperatures as low as 35 deg F.
  - 5. UL94 Class HBF fire retardant rating.

## 2.4 POLYMER CONCRETE HANDHOLES AND BOXES

- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Armorcast
  - 2. NewBasis
  - 3. Oldcastle
  - 4. Hubbell Quazite
- C. General Requirements:
  - 1. Comply with SCTE 77. Minimum Tier 15.

2. Color: Gray.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, as indicated for each service.

## 2.5 PRECAST CONCRETE MANHOLES AND HANDHOLES

- A. Description: Factory fabricated, one-piece units and units with interlocking mating sections, complete with accessories, hardware, and features. Frame and cover shall have load rating consistent with that of structure.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  1. Christy Concrete Products
  2. Oldcastle
  3. Utility Concrete Products
  4. Utility Vault Co
- C. Comply with ASTM C 858.
- D. Precast reinforced-concrete, H-20 structural load rating according to AASHTO HB 17.
- E. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
  1. Locate windows no less than 6 inches from interior surfaces of walls, floors, or roofs of structure, but close enough to corners to facilitate racking of cables on walls.
  2. Provide window opening with cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
  3. Provide window opening frame with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
  4. Provide windows 1-1/2 to 2 inches thick.
- F. Duct Entrances in Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
  1. Type and size shall match fittings to duct or conduit to be terminated.
  2. Fittings shall align with elevations of approaching ducts and be located near interior corners of structures to facilitate racking of cable.
- G. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
- H. Provide ventilation openings where indicated on drawings.

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- I. Frames, Covers, and Chimney Components: Comply with structural design loading specified for structure.
1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 35 cast iron with milled cover-to-frame bearing surfaces; diameter, 32 inches.
    - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
    - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
  2. Cover Legend: Cast in. Selected to suit system.
    - a. All covers shall be provided with 2-inch lettering and with the structure number, assigned by Owner, welded onto the cover if not provided by the manufacturer.
    - b. All covers shall be provided with stainless steel drop handles.
  3. Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
    - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
    - b. Seal joints watertight using preformed plastic or rubber conforming to ASTM C 990. Install sealing material according to the sealant manufacturers' printed instructions.
- J. Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- K. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch diameter eye, and 1-by-4 inch bolt.
  1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.
- L. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
  1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
- M. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
- N. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- O. Ground Rod Sleeve: 3-inch, PVC conduit sleeve in floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.
- P. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.
- Q. Cable Rack Assembly: Steel, hot dip galvanized, except insulators.
  1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
  2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for

cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.

3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
- R. Fixed Ladders & Extension: Arranged for attachment to wall of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.

## 2.6 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by an independent testing agency.
  2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
  3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there are obstructions or conflicts between areas of excavation and existing structures or archaeological features to remain.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.
- C. All necessary precautions shall be taken by the contractor during construction to prevent the lodging of dirt, plaster or trash in all conduit, tubing, fittings and boxes.

### 3.2 UNDERGROUND DUCT APPLICATION

- A. Apply underground duct products as specified unless noted otherwise:
1. Refer to Section 260533, "Raceways and Boxes for Electrical Systems" for additional requirements related to underground conduit below building slabs.
  2. Ducts for Utility Company primary conductors: comply with utility company standards unless noted otherwise.



3. Ducts for Electrical Service Secondary Conductors: RNC, Type EPC-40 PVC, in concrete-encased duct bank unless otherwise indicated.
  4. Ducts for Electrical Cables greater than 600 V: RNC, Type EPC-40 PVC, in concrete-encased duct bank unless otherwise indicated.
  5. Ducts for Electrical Feeders 600 V and Less: RNC, Type EPC-40 PVC, in concrete-encased duct bank unless otherwise indicated.
  6. Ducts for Electrical Branch Circuits: RNC, Type EPC-40 PVC, in direct buried duct bank unless otherwise indicated.
  7. Ducts for Communications Cables: RNC, Type EPC-40 PVC, in direct buried duct bank unless otherwise indicated.
  8. Underground Ducts 600V and less Crossing Driveways and Roadways: RNC, Type EPC-40-PVC, encased in reinforced concrete. Extend reinforcement a minimum of 5-feet beyond the edge of paved surfaces.
- B. Minimum Cover Requirements: Provide reinforced concrete encasement where minimum depths are not achievable.
1. Electrical Primary or Conductors more than 600V: 48-inches unless otherwise indicated by utility company requirements.
  2. Electrical Secondary Service and Feeders: 36-inches
  3. Electrical Branch Circuits: 24-inches
  4. Communications: 30-inches
- C. Transition RNC to GRC for all stub-ups and building enclosure penetrations. Use fittings manufactured for RNC-to-GRC transition.
1. Arrange stub-ups so curved portions of bends are not visible above grade. Increase burial depth where required to maintain cover for curves and bends.
  2. Do not use steel raceways for equipment stub-ups where prohibited by utility company standards.
- D. Minimum Underground Raceway Size: 1-inch trade size unless noted otherwise on the drawings.

### 3.3 EARTHWORK

- A. Contractor shall accept the site as they find it and remove all trash, rubbish, and material from the site prior to starting excavation work.
- B. Subsurface Data
1. Subsurface investigations have been performed and the results provided with the contract documents. The information was obtained primarily for use in preparing foundation design. Each contractor may draw their own conclusions therefrom. No responsibility is assumed by the Owner for subsoil quality or conditions other than at the locations and at the time the investigations were made.
  2. Materials to be excavated shall be unclassified, and shall include earth, rock, or any other material encountered in the excavation to the depth and extent indicated on the drawings and specified herein. No adjustment in the contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in excavating.

C. Benchmarks and Monuments

1. Carefully maintain all benchmarks, monuments, and other reference points. If disturbed or destroyed, replace as directed.

D. Excavation:

1. Remove rock by using hand or power tools only. Blasting is not permitted unless authorized in writing by the Architect.
2. Any damage to existing structures, exterior services, or rock intended for bearing shall be corrected by the Contractor at their own expense.
3. Take necessary precautions to control runoff of eroded earth onto the property of others or against the structures. All such damage or any other damage incurred in the course of excavation, shall be corrected by the Contractor at their own expense.

E. Trenching:

1. Cut trenches neatly and uniformly. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.
2. Width: Excavate trench a minimum of 3 inches wider than duct bank on each side with a minimum trench width of 12-inches.
3. Depth: Excavate to a minimum depth that equals ductbank height plus minimum cover requirements.
4. Hand excavate trench bottom to provide uniform bearing and support of conduits on an undisturbed subgrade matching slope requirement. Remove all debris, stones, and other projections.
  - a. For rock or other unyielding soils, excavate trenches 6-inches deeper than required elevation and provide level 6-inch compacted sand bedding course.
  - b. For unstable soils or where bedding course is subject to washout, provide concrete trench bottom.
5. Coordinate protection of roots in tree and plant protection zones with Division 31 requirements.
6. Keep trenches free from water while construction is in progress. Installation of conduit or cable in trenches with water is not permitted. Contractor is responsible for all costs associated with dewatering of trenches.

F. Final Backfill: Comply with Division 31 and as indicated below:

1. Use satisfactory soil to backfill trenches to final subgrade elevation unless required otherwise by Civil or Structural subgrade requirements.
2. Install final backfill in 6-inch layers.
3. Compact all backfill to 95% standard proctor density.
4. Mechanical means for compaction can be used once conduits have been covered with at least 12-inches of hand tamped backfill. Do not use heavy-duty, hydraulic-operated, compaction equipment.

G. Restoration:

1. Replace area immediately after backfilling is completed or after construction in immediate area is complete.
2. Restore all surface features at areas disturbed by excavation, storing of dirt, cable laying, and other work, and re-establish original grades unless otherwise indicated.

3. Restore vegetation and include 6-inches of clean topsoil, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32.
- H. Cut and patch existing pavement in the path of underground ducts and utility structures according to the "Cutting and Patching" requirements in Division 01 and Section 260010, "General Requirements for Electrical".

### 3.4 DUCT INSTALLATION

- A. Install ducts, spacers, and accessories into ductbank configurations to accommodate duct quantities and sizes indicated on drawings.
- B. Install ducts according to NEMA TCB 2.
- C. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions. Install ducts in such a manner to avoid traps and insure against collection of moisture.
- D. Curves and Bends:
  1. Use 5-degree angle couplings for small changes in direction.
  2. Use manufactured long sweep bends with a minimum radius of 36 inches vertically and 60-inches horizontally, unless otherwise indicated.
  3. Field manufactured bends are acceptable for a bend radius greater than 35-feet. Install field bends in accordance with NEMA TCB 2.
  4. Electrical duct and duct banks: Install no more than the equivalent of three 90-degree bends in any conduit run.
  5. Communications duct and duct banks: Install no more than the equivalent of two 90-degree bends in any conduit run and a maximum of 600 feet between pull points.
- E. Joints: Use solvent-cemented joints in non-metallic ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same horizontal or vertical plane to ensure encasement or backfill fully surrounds each raceway.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, provide minimum 6-foot separation or perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. Installation Adjacent to Other Utilities:
  1. Provide minimum 12-inches of earth or 3-inches of concrete between power and communications ducts.
  2. Provide minimum 24-inches of earth between power or communications ducts and other parallel utilities. At utility crossings, provide minimum 6-inches of separation except

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- provide 12-inches separation where crossing utility is gas or other line that transports flammable material.
3. Do not locate power and communications ducts below water and sewer lines.
- H. Duct Entrances to Manholes and Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
  2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch (19 mm).
  3. Grout end bells into structure walls from both sides to provide watertight entrances.
- I. Building Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Provide sleeves at building penetration and make water-tight with sleeve seal.
- J. Duct Support
1. For concrete encased applications, support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
  2. Separator Installation: Space separators at a maximum of 5-feet to prevent sagging and deforming of ducts. Place spacers within 24-inches of duct ends. Stagger separators approximately 6 inches between tiers.
  3. Minimum Space between Ducts: 3 inches between ducts and between ducts and exterior envelope wall.
- K. Concrete-Encased Ducts:
1. Secure separators to earth and to ducts to prevent floating during encasement. Tie entire assembly together using non-ferrous tie-wires or straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
  2. Reinforcement: Where indicated, reinforce concrete-encased duct banks for their entire length. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
  3. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
  4. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct and exterior envelope wall.
  5. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.

- b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
  - 6. Concrete Encasement:
    - a. Use normal strength concrete, minimum 3000 psi at 28 days, 6-to-8-inch slump, with maximum 1/2 inch aggregate.
    - b. Comply with requirements in "Concrete Placement" Article in Division 03. Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope.
    - c. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces.
    - d. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
  - 7. Complete final backfilling after concrete has cured.
- L. Direct-Buried Duct Banks:
  - 1. Set elevation of bottom of duct bank below frost line.
  - 2. After installing first tier of ducts, install initial backfill and compact.
  - 3. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process.
  - 4. Perform initial backfilling/encasement in 2-inch lifts. Compact to 95% standard proctor density.
  - 5. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over ducts and hand tamp.
  - 6. Firmly tamp initial backfill around ducts to provide maximum supporting strength. Use hand tamper only.
  - 7. After placing initial backfill over final tier, make final duct connections at end of run and complete backfilling.
  - 8. Initial backfill/encasement material shall be crushed stone, sand, or pea gravel with a maximum aggregate size of 1/2-inch.
- M. Warning Tape: Bury warning tape approximately 12 inches above all ducts. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.
- N. Install pull tape in all spare ducts with 3ft of slack tied off and secured at each pull point.
- O. Duct Sealing:
  - 1. Provide temporary plugs of all ducts upon completion of each portion of work to prevent ingress of foreign material into the duct.
  - 2. After conductors have been installed seal all ducts, including spare ducts, at building entrances and equipment terminations. Use sealing compound and foam plugs capable of withstanding at least 15-psig hydrostatic pressure.

### 3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

#### A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

#### B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.

#### C. Where indicated, cast handhole cover frame integrally with handhole structure.

#### D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

#### E. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. After ducts have been connected and grouted, and before backfilling, waterproof joints, and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

#### F. Hardware: Turn over removable hardware, including pulling eyes, cable stanchions, cable arms, to Construction Manager for use during next phase.

#### G. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

#### H. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

### 3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

#### A. Install hand-holes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.

- B. Unless otherwise indicated, support units on a 12-inch thick level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade. Install handholes and boxes with bottom below frost line.
- D. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- E. For enclosures installed in asphalt paving, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
  - 1. Concrete: 3000 psi, 28-day strength, complying with Division 03, with a troweled finish.
  - 2. Dimensions: minimum 10 inches wide and 12 inches deep or as shown on drawings.

### 3.7 GROUNDING

- A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems".
  - 1. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide #1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.
  - 2. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with #4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

### 3.8 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems".
  - 1. Where ducts transition through manholes or handholes, and at each termination point, provide each duct with a unique identifier to indicate origination point.
  - 2. Cover legends shall be consistent with the owner's standard practices, especially within existing facilities, unless otherwise require by codes.

### 3.9 FIELD QUALITY CONTROL

- A. Prior to covering duct or underground structures, perform visual inspections to verify the following:
  - 1. Proper installation depths and slopes have been maintained.
  - 2. Proper vertical and horizontal spacing in multi-duct formations.
  - 3. All conduit sections have been properly jointed.
  - 4. Proper bend radius of curved sections have been maintained.
  - 5. Check for damage at changes in grades or at bends.
- B. Perform the following tests and inspections and prepare test reports:
  - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
  - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for duct deflections or out of round conditions. Provide a minimum 6-inch- long mandrel 1/2-inch smaller in diameter than diameter of duct. If obstructions are discovered, remove obstructions and retest.
- C. Correct deficiencies, replace affected duct sections, and retest as specified above to demonstrate compliance.
- D. Prepare detailed test and inspection reports with accompanying digital photographs.
- E. Concealed Work Photographs: Before proceeding with installing backfill that will conceal work, take photographs sufficient in number, with annotated descriptions, to record nature and location of concealed Work.

### 3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of all ducts until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes and handholes, including sump. Remove dirt and foreign material.

END OF SECTION 260543



## SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Equipment Nameplates.
  - 2. Cable and Conductor Labels.
  - 3. Wiring Device Labels
  - 4. Safety Labels.
  - 5. Instruction Signs.
  - 6. Miscellaneous identification products.
- B. Related Requirements
  - 1. Refer to Section 260573, "Power System Studies" for additional requirements related to fault current and arc flash labeling.
  - 2. Refer to Section 270553, "Identification for Communications Systems" for additional requirements related to labeling of communications equipment and cabling.

#### 1.3 REFERENCES

- A. Abbreviations
- B. Definitions
  - 1. Emergency Systems: Those systems legally required and classed as emergency by NFPA 70 Article 700, municipal, state, other codes, or by any government agency having jurisdiction.
  - 2. Essential Electrical Systems: Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and to minimize disruption within the internal wiring system.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. American National Standards Institute (ANSI)
    - a. ANSI Z535.4, "Product Safety Signs and Labels"

2. National Fire Protection Association (NFPA)
  - a. NFPA 70E, "Standard for Electrical Safety in the Workplace"
3. Occupational Safety and Health Administration (OSHA)
  - a. 29 CFR 1910.144, "Safety color code for marking physical hazards"
  - b. 29 CFR 1910.145, "Specifications for accident prevention signs and tags"
4. Underwriters Laboratories Inc (UL)
  - a. UL 969, "Marking and Labeling Systems"

#### 1.4 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
  1. Include project specific examples of each label type.
- B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- C. Closeout Submittal:
  1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Provide electronic Excel files of all panelboard directories to owner as part of Close-out Documentation.

#### 1.5 COORDINATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes and standards. Use consistent designations throughout Project.
- B. All identifications shall be consistent with the owner's standard practices, especially within existing facilities, unless otherwise require by codes. Where the requirements herein are in conflict, the contractor shall notify the engineer in writing prior to ordering any material.
- C. All room names and/or numbers for labeling or programming shall use the Owner's approved room name and numbering scheme, not names and numbers indicated on floor plans. All reprogramming shall be included as required to accommodate construction phasing.
- D. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- E. Coordinate installation of identifying devices with location of access panels and doors.
- F. Install identifying devices before installing acoustical ceilings and similar concealment.

## PART 2 - PRODUCTS

### 2.1 EQUIPMENT SIGNS AND NAMEPLATES

#### A. Engraved Plastic Signs and Nameplates.

1. 3-layer melamine plastic laminate
2. Weather and UV-resistant for Wet and Damp Locations.
3. Thickness:
  - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
  - b. For signs larger than 20 sq. in. or 8 inches in length, 1/8 inch thick.
  - c. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
  - d. Framed with mitered melamine molding and arranged for attachment at applicable equipment.
4. Color: Comply with color legend.

### 2.2 RACEWAY AND CONDUCTOR LABELS

#### A. Raceway Labels: Pre-printed, self-adhesive, polyester, suitable for indoor or outdoor use, resistant to abrasion, humidity, and weather.

1. Color: Black Letters on an orange field.
2. Size: For each raceway size, comply with ANSI/ASME A13.1 for recommended letter height and field length.

#### B. Wire and Cable Labels: Machine printed, self-adhesive, polyester, self-laminating, suitable for indoor or outdoor use on flexible cables, resistant to abrasion, humidity, and weather.

### 2.3 SAFETY SIGNS AND LABELS

#### A. Comply with NFPA 70 and 29 CFR 1910.145.

#### B. All field-applied hazard markings shall warn of hazards using effective words, colors, symbols, or any combination thereof as recommended by ANSI Z535.4-2011. This applies to all instances where caution, warning, or danger signs are required per the NEC and applicable OSHA standards.

#### C. Self-Adhesive Safety Labels: Polyester, Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for intended use and suitable for installed environment.

#### D. Provide UV overlaminating film for outdoor locations.

### 2.4 INSTRUCTION SIGNS

#### A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

- B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

## 2.5 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Floor Marking Tape: 2-inch wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
- B. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system suitable for surface material and location (exterior or interior).
- C. Fasteners for Labels and Signs:
  - 1. Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.
  - 2. Pop-Rivets.
  - 3. Two-Part Epoxy Adhesive
- D. Cable Ties: Self-extinguishing, one-piece, self-locking, UV-stabilized or plenum rated where required by installed environmental conditions. 3/16-inch minimum width.

## PART 3 - EXECUTION

### 3.1 GENERAL REQUIREMENTS

- A. Verify identity of each item before installing identification products.
- B. Before installation of labels, clean all surfaces using materials and methods recommended by manufacturer of identification device.
- C. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- E. Install all labels in a neat manner, plumb and parallel to equipment lines.
- F. Attach plastic signs and labels to equipment with mechanical fasteners appropriate to the location and substrate. Where screws cannot or should not penetrate substrate use two-part epoxy adhesive listed for use with intended substrate and environmental conditions.
- G. Handwritten, non-permanent, or stenciled labels are not permitted unless noted otherwise.
- H. For surfaces that require finish work, apply identification devices to surfaces after completing finish work.

- I. Identification shall consist of all UPPER-CASE LETTERS.
- J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

### 3.2 EQUIPMENT IDENTIFICATION

- A. Provide all new and modified equipment with a nameplate consisting of 1/2" letters for equipment designation and 1/4" letters for voltage, source, and feeder information. This includes but is not limited to panelboards, switchboards, switchgear, disconnect switches, transformers, power transfer equipment, generators, motor starters, variable frequency drives, lighting control panels, contactors, cabinets, push button stations, and auxiliary system control panels.
- B. Distribution equipment labels shall indicate the following:
  - 1. Equipment designation.
  - 2. Voltage system.
  - 3. Equipment ampacity.
  - 4. Source equipment designation and location.
  - 5. Feeder size.
- C. Transformer labels shall indicate the following:
  - 1. Equipment designation.
  - 2. Primary voltage system and primary feeder ampacity.
  - 3. Source equipment designation and location.
  - 4. Primary feeder size.
  - 5. Secondary voltage system and load equipment designation
- D. Equipment disconnect labels shall indicate the following:
  - 1. Equipment designation.
  - 2. Voltage system and feeder ampacity
  - 3. Source equipment designation and location.
- E. Locate equipment nameplates at center of top of trim for branch circuit panels, switchgear, and centered at side for branch circuit switches.
- F. Where equipment is provided with a factory installed disconnecting means or motor controller, install label on factory provided unit.
- G. For equipment with multiple power sources, such as transfer switches and control panels, identify each source and its function.
- H. Color Legend
  - 1. Normal Power Systems: Black field with white letters
  - 2. Emergency Power Systems (As defined by NEC Article 700): Red field with white letters.

- I. Where electrical distribution equipment, including panelboards, switchboards, and switchgear, are connected to an emergency source, the nameplate shall incorporate the word "EMERGENCY" into the legend. Refer to drawings for further details.
- J. Where the premise wiring system has feeders and/or branch circuits supplied from more than one nominal voltage system, provide sign at each switchgear, switchboard, and panelboard displaying color coded identification method for each ungrounded, grounded, and equipment grounding conductor.
- K. Service Equipment and Building Feeder, Branch Circuit Disconnects.
  - 1. Provide label for service disconnecting means to permanently identify it as the "SERVICE DISCONNECT".
  - 2. Where a building or structure has any combination of feeders, branch circuits, or services passing through it or supplying it, provide a permanent sign at each disconnect location identifying all other feeders, branch circuits, or services and the area served by each.

### 3.3 IDENTIFICATION OF CONDUCTORS

- A. Service, Feeder, and Branch-Circuit Conductors: Refer to Section 260519, "Low Voltage Electrical Power Conductors and Cables" for conductor and cable color coding requirements.
- B. Indicate source and circuit number of conductors to be extended in the future.
- C. Auxiliary Systems Alarm, Signal, and Control Wire Identification: At termination points, identify each conductor by its system, designation, and function.

### 3.4 IDENTIFICATION OF RACEWAYS AND BOXES

- A. Identify all junction, outlet, device, and pull boxes with wiring system, voltage, and circuit designations of conductors.
  - 1. In concealed locations above accessible ceilings and in exposed unfinished areas such as data, mechanical, or electrical rooms, provide designations on outside of box covers.
  - 2. For exposed boxes in finished areas, provide designations on inside of box covers.
  - 3. System Legend shall be as follows:
    - a. Power
    - b. Emergency
    - c. UPS
- B. The inside of all junction and backboxes shall be marked with panel and circuit number in permanent marker.
- C. All empty conduit runs and conduit with conductors for future use shall be identified for use and shall indicate where they terminate.

### 3.5 IDENTIFICATION OF WIRING DEVICES

- A. All new and existing receptacle cover plates in area of work shall be marked with their panel and circuit number(s) with clear, machine printed adhesive labels with black lettering.

### 3.6 PANELBOARD CIRCUIT DIRECTORIES

- A. For Distribution Panelboards, Switchboards, and Switchgear, provide nameplates at each switch or circuit breaker to indicate load designation.
- B. Provide clearly legible typewritten directories in each electrical panel indicating the area, item of equipment, etc. controlled by each switch, breaker, fuse, etc. These directories are to be inserted into plastic cardholders on back door in each panel. Descriptions shall identify each circuit as to its clear, evident, and specific purpose or use. The identification shall include an approved degree of detail that allows each circuit to be distinguished from all others. Spaces and Spare positions shall be described accordingly.
  - 1. At a minimum, provide the following panel information for each panel directory:
    - a. Panel name
    - b. Panel bus rating
    - c. Voltage System
    - d. Mains Configuration and Rating
    - e. Short Circuit Current Rating
  - 2. Circuit Designation Examples:
    - a. LIGHTS, ROOM 100
    - b. FLOOR RECEPTACLES, ROOM 200
    - c. ERV-1 RECEPTACLE, ROOF
- C. Panel Schedules and circuit numbers on Record Drawings shall match.

### 3.7 SAFETY SIGNS

- A. Install Warning, Caution, and Danger signs in accordance with NFPA 70 and OSHA requirements to ensure safe operation of electrical equipment and the items to which they connect.
- B. Comply with 29 CFR 1910.145 and ANSI Z535.4.
- C. Apply to exterior of door, cover, or other access point.
- D. Labels and signs shall include, but are not limited to, the following legends:
  - 1. Identify system voltage with black letters on an orange background.
  - 2. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
  - 3. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES"

4. Where series combination ratings are allowed: "CAUTION - SERIES COMBINATION SYSTEM RATED \_\_\_\_ AMPERES. IDENTIFIED REPLACEMENT COMPONENTS REQUIRED."

### 3.8 INSTRUCTION SIGNS

- A. Operating Instruction Signs: Install instruction signs with minimum 3/8-inch letters to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation, power transfer, and load shedding.

### 3.9 WORKSPACE INDICATION

- A. Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install flush-mounted panelboards and similar equipment in finished spaces.

END OF SECTION 260553



## SECTION 260573 - POWER SYSTEM STUDIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Section includes the following computer-based studies:
  - 1. Fault-current study to determine the minimum interrupting capacity of circuit protective devices.
  - 2. Overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
  - 3. Arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.
- B. Related Requirements
  - 1. Refer to Section 260553, "Identification for Electrical Systems" for label material and performance requirements.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. SCCR: Short-circuit current rating.
- B. Definitions
  - 1. Emergency Electrical Systems: Those systems legally required and classed as emergency by NFPA 70 Article 700, municipal, state, other codes, or by any government agency having jurisdiction.
  - 2. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.
  - 3. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
  - 4. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
  - 5. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

6. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
  7. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
  8. Single-Line Diagram: See "One-Line Diagram."
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
1. Institute of Electrical and Electronics Engineers (IEEE)
    - a. IEEE 141 - Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
    - b. IEEE 241 - Recommended Practice for Electric Power Systems in Commercial Buildings
    - c. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
    - d. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis
    - e. IEEE 551 - Recommended Practice for Calculating AC Short-Circuit Currents in Industrial and Commercial Power Systems
    - f. IEEE 1015 - Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
    - g. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations
    - h. IEEE 3002.3 - IEEE Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems
  2. American National Standards Institute (ANSI)
    - a. ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
    - b. ANSI C37.13 - Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
    - c. ANSI C37.010 - Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
    - d. ANSI C 37.41 - Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
  3. The National Fire Protection Association (NFPA)
    - a. NFPA 70E - Standard for Electrical Safety in the Workplace

#### 1.4 SEQUENCING

- A. The short-circuit and protective device coordination studies shall be submitted for review prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing.
- B. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

## 1.5 SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Initial Study Report: The study shall provide sufficient data to ensure that selection of equipment and devices will have adequate ratings and the protective device trip characteristics will be satisfactory. Include the following:
  - 1. Study input data, including completed computer program input data sheets including assumptions on worst case project conditions.
  - 2. Study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
- C. Final Study and Report: Submit final study at the end of the construction when all circuits are installed and all equipment is on site and installed such that complete and accurate data can be obtained.
- D. Closeout Submittals
  - 1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Provide five (5) bound copies of the complete final report. Additional copies shall be provided on CD or USB in PDF format.
    - b. Certification Document to confirm system settings have been implemented.
    - c. Provide the study project files in electronic format including all project files and libraries to allow the owner to update and print additional copies, labels, etc. This includes copies of the actual models from the power system analysis software and all associated files required to support the model(s).

## 1.6 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are not acceptable.
- D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located and skilled in performing and interpreting the power system studies. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
  - 1. Engineer shall be a full-time employee of the electrical equipment manufacturer.
  - 2. The engineer shall have a minimum of five (5) years' experience performing power system studies.
- E. Power System Study Certification: Report shall be signed and sealed by Power Systems Analysis Specialist.

F. Field Adjusting Personnel Qualifications:

1. Technician shall be a full-time employee of the electrical equipment manufacturer.
2. Technician responsible for all field adjusting of the Work shall have a minimum NICET Electrical Power Testing Level III certification or equivalent.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

- A. Perform studies using the latest version of one of the following:
1. Power Tools for Windows by SKM Systems Analysts.
  2. ETAP by Operation Technology, Inc.
  3. EasyPower by Easypower, LLC
- B. Comply with IEEE 242, IEEE 399, IEEE 551, IEEE 1584, IEEE 3002.3, and NFPA 70E.
- C. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 POWER SYSTEM STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
1. Protective device designations and ampere ratings.
  2. Conductor types, sizes, and lengths.
  3. Transformer kilovolt ampere (kVA) and voltage ratings.
  4. Motor and generator designations and kVA ratings.
  5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
  6. Derating factors and environmental conditions.
  7. Any revisions to electrical equipment required by the study.
- D. Study Input Data
1. Available Power source data.
  2. Manufacturer, model, and interrupting rating of protective devices.
  3. Conductors.
  4. Transformer data.

- E. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.
- F. Protective Device Evaluation:
  - 1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment SCCR ratings exceed available short-circuit current at equipment installation locations.
  - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
  - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
  - 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that SCCR ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- G. Short-Circuit Study Output Reports:
  - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Equivalent impedance.
  - 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Calculated asymmetrical fault currents:
      - 1) Based on fault-point X/R ratio.
      - 2) Based on calculated symmetrical value multiplied by 1.6.
      - 3) Based on calculated symmetrical value multiplied by 2.7.
  - 3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. No AC Decrement (NACD) ratio.
    - e. Equivalent impedance.
    - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
  - a. Phase and Ground Relays:
    - 1) Device tag.
    - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
    - 3) Recommendations on improved relaying systems, if applicable.
  - b. Circuit Breakers:
    - 1) Adjustable pickups and time delays (long time, short time, and ground).
    - 2) Adjustable time-current characteristic.
    - 3) Adjustable instantaneous pickup.
    - 4) Recommendations on improved trip systems, if applicable.
2. Fuses: Show current rating, voltage, and class.

I. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
  - a. Power utility's overcurrent protective device.
  - b. Medium-voltage equipment overcurrent relays.
  - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
  - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
  - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
  - f. Cables and conductors damage curves.
  - g. Ground-fault protective devices.
  - h. Motor-starting characteristics and motor damage points.
  - i. Generator short-circuit decrement curve and generator damage point.
  - j. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Maintain selectivity for tripping currents caused by overloads.
6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.

7. Provide adequate time margins between device characteristics such that selective operation is achieved.
8. Comments and recommendations for system improvements.

J. Arc-Flash Study Output Reports:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

K. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Restricted approach boundary.
6. Limited approach boundary.
7. Working distance.
8. Incident energy.
9. Hazard risk category.
10. Recommendations for arc-flash energy reduction.

## 2.3 ARC-FLASH WARNING AND AVAILABLE FAULT CURRENT LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each location indicated in the analysis unless noted otherwise.
- B. Arc Flash Warning Labels shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include all information required by NFPA 70E and the following information taken directly from the arc-flash hazard analysis:
  1. Location designation.
  2. Engineering report number, revision number, and issue date.
- C. Available Fault Current Labels shall have an orange header with the wording, "WARNING", and shall include the following information taken directly from the short circuit study.
  1. Location designation.
  2. Maximum available fault current.
  3. Calculation date.
  4. Engineering report number, revision number, and issue date.

- D. Labels shall be machine printed, with no field-applied markings.

## PART 3 - EXECUTION

### 3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the study.
1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Engineer's attention.
  2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
  3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. Qualifications of technicians and engineers shall be as defined by NFPA 70E.
- B. Electrical Survey Data: Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study. Data includes, but is not limited to, the following:
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  2. Electrical power utility impedance and available short circuit current at the service.
  3. Power sources and ties.
  4. Short-circuit current at each system bus (three phase and line to ground).
  5. Full-load current of all loads.
  6. Voltage level at each bus.
  7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
  8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
  9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
  10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
  11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
  12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
  13. Motor horsepower and NEMA MG 1 code letter designation.



14. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Derating factors.
16. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:
  - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
  - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
  - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
  - d. Generator thermal-damage curve.
  - e. Ratings, types, and settings of utility company's overcurrent protective devices.
  - f. Special overcurrent protective device settings or types stipulated by utility company.
  - g. Time-current-characteristic curves of devices indicated to be coordinated.
  - h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
  - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
  - j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
  - k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

### 3.2 POWER SYSTEMS STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Base study on device characteristics supplied by device manufacturer.
- C. Gather all necessary data from the existing facility as needed to perform the study.
- D. The Contractor shall be responsible for modifying settings on existing equipment only at over-current protection devices upstream of new equipment unless noted otherwise.
- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

- G. Identify in the report any protective device applied outside its capacity.
- H. Short Circuit Study
  - 1. Calculate short-circuit currents according to IEEE 551.
  - 2. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
    - a. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
  - 3. Evaluate equipment and protective devices and compare to short-circuit ratings.
- I. Coordination Study
  - 1. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
  - 2. Transformer Primary Overcurrent Protective Devices:
    - a. Device shall not operate in response to the following:
      - 1) Inrush current when first energized.
      - 2) Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      - 3) Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
    - b. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
  - 3. Motor Protection:
    - a. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
    - b. Select protection for motors served at voltages more than 600 V according to IEEE 620.
  - 4. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
  - 5. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.
- J. Arc Flash Hazard Analysis
  - 1. Comply with NFPA 70E and its Annex D for hazard analysis study.
  - 2. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.
  - 3. Calculate maximum and minimum contributions of fault-current size.
    - a. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
    - b. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
  - 4. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

5. Include medium- and low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers less than 125 kVA.
6. Calculate the limited and restricted approach boundaries for each location.
7. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
  - a. Fault contribution from induction motors shall not be considered beyond three to five cycles.
  - b. Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
8. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:
  - a. When the circuit breaker is in a separate enclosure.
  - b. When the line terminals of the circuit breaker are separate from the work location.
9. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

### 3.3 LABELING

- A. All labels will be based on recommended overcurrent device settings and will be provided to owner after the results of the analysis have been presented and after any system changes, upgrades, or modifications have been incorporated in the system.
- B. Arc Flash Labeling:
  1. Provide and install an arc-flash label for each piece of electrical equipment listed below and each piece of equipment that is likely to require examination, adjustment, servicing, or maintenance while energized:
    - a. Motor-control centers.
    - b. Switchboards.
    - c. Switchgears.
    - d. Meter Enclosures.
    - e. Medium voltage and low voltage transformers
    - f. Panelboards.
    - g. Equipment Control panels.
    - h. Motor Controllers.
    - i. Disconnect Switches.
  2. Apply arc-flash label on the front cover of each section of the equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.

C. Available Fault Current Labeling

1. Provide and install an available fault current label for each piece of electrical equipment listed below:
  - a. Service equipment.
  - b. Elevator Control Panel.

D. Install warning labels under the direction of the Power System Analysis Specialist.

E. Provide new labels for any existing equipment to remain with updated values based on the results of the analysis.

3.4 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by a qualified technician from the engineering service division of the equipment manufacturer.

B. Make modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Notify Architect and Engineer in writing of any required major modifications.

D. Equipment shall not be energized until all breakers or protective relays are set either to the recommended values indicated by the studies or to minimum trip settings.

E. Certification: Prior to project Substantial Completion, submit four signed copies of a document certifying that the settings and selection scope has been completed as specified.

3.5 DEMONSTRATION

A. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.

B. Hand-out and explain the power system study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.

C. Arc Flash Training

1. Train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels (minimum of 4 hours).
2. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET) or equivalent.

3. Include in Project Close-out Documents training notes, outlines, and Power Point presentation of training session. Also include attendance record of personnel attending the training session.

END OF SECTION 260573

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## SECTION 260913 - ELECTRICAL POWER MONITORING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Multi-function power meters
  - 2. Energy meters
  - 3. Multi-circuit energy meters
  - 4. Accessories
- B. Related Requirements:
  - 1. Refer to Division 25 for interface with building automation and data acquisition network.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. CT: Current Transformer
  - 2. EM: Energy Meter
  - 3. MCM: Multi-Circuit Meter
  - 4. PM: Power Meter
- B. Definitions
  - 1. Active Power: The average power consumed by a unit. Also known as "real power."
  - 2. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
  - 3. Apparent (Phasor) Power: " $S = VI$ " where "S" is the apparent power, "V" is the RMS value of the voltage, and "I" is the RMS value of the current.
  - 4. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
  - 5. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.
- C. Reference Standards
  - 1. American National Standards Institute (ANSI)
    - a. ANSI C12.20, "Electricity Meters - 0.2 and 0.5 Accuracy Classes."

2. Underwriters Laboratories, Inc. (UL):
  - a. UL 61010, "Electrical Equipment for Measurement, Control, and Laboratory Use."
  - b. UL 61010-1, "Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements."

#### 1.4 COORDINATION

- A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
  1. Match components and interconnections for optimum performance of specified functions.
- B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

#### 1.5 PREINSTALLATION MEETING

- A. Schedule preconstruction conference with Architect, Engineer, Owner, and all affected trades. Agenda topics should include, but are not limited to, the following:
  1. Communication network wiring requirements.
  2. Wire labelling.
  3. Current Transformer (CT) and metered load locations.
  4. Static IP addresses and Gateway requirements for proper communication with building automation and data acquisition system.

#### 1.6 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Provide the following
  1. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
  2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
  3. Include diagrams for power, signal, network, and control wiring. Coordinate nomenclature and presentation with a block diagram.
- C. Field quality-control reports.
- D. Closeout Submittals
  1. Operation and Maintenance Data: For metering and components to include in operation and maintenance manuals.
  2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:



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

## 1.7 MAINTENANCE MATERIAL

- A. Extra Stock Materials: Provide one set of each type of power and control fuses installed within equipment.

## 1.8 WARRANTIES

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace meters, controls, wiring, and all of its components that fail in materials or workmanship within 5 years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated on Drawings or comparable product by one of the following:
  - 1. ABB
  - 2. Eaton
  - 3. Siemens
  - 4. Square D
- B. Source Limitations: Obtain metering devices, and all other electrical distribution equipment through one source from a single manufacturer.

### 2.2 GENERAL REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Addressable Devices: Transmitters and receivers must communicate unique device identification and status reports to monitoring and control clients.
- C. Interface with building automation and data acquisition system: Provide factory-installed hardware and software to enable the building automation and data acquisition system to monitor, display, and record data for use in processing reports.
  - 1. BACnet IP communication interface with the building automation and data acquisition system must enable the system operator to remotely monitor meter information from a system workstation. Control features and monitoring points displayed locally at metering panel must be available through the building automation and data acquisition system.

## 2.3 MULTI-FUNCTION POWER METERS

- A. Description: Modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.
  - 1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
- B. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- C. Accuracy: Comply with ANSI C12.20, Minimum Class 0.2.
- D. Communications:
  - 1. Integral ethernet to serial gateway
  - 2. One RS-485 serial port with Modbus RTU
  - 3. Two Ethernet ports capable of both Modbus TCP/IP and BACnet IP.
- E. Meter Physical Characteristics:
  - 1. Display: Backlit LCD with antiglare and scratch-resistant lens.
  - 2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display must include the following:
    - a. Meters, including those listed under the following:
      - 1) Measurements.
      - 2) THD.
      - 3) Energy.
      - 4) Demand.
      - 5) Minimum and maximum values.
      - 6) Power demand.
- F. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 128 samples per cycle, simultaneously on voltage and current channels of the meter.
- G. Meters:
  - 1. Measurements: Instantaneous, in real time, RMS to the 63rd harmonic.
    - a. Voltage: L-L each phase, L-N each phase, and three-phase average.
    - b. Current: Each phase, three-phase average, and neutral.
    - c. Unbalanced current, L-L V(ac) and L-N V(ac).
    - d. Active Power (+/- kW): Each phase and three-phase total.
    - e. Reactive Power (+/- kVAR): Each phase and three-phase total.
    - f. Apparent Power (+/- kVA): Each phase and three-phase total.
    - g. Displacement Power Factor: Each phase and three-phase total.
    - h. Distortion Power Factor: Each phase and three-phase total.
    - i. Frequency.
  - 2. THD from measurements simultaneously from the same cycle, through 63rd harmonic.
    - a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
    - b. Current THD: Each phase and three-phase average.

- 
- c. Total demand distortion.
  - 3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.
    - a. Active kWh.
    - b. Reactive kVARh.
    - c. Apparent kVAh.
  - 4. Demand: Present, last, predicted, peak.
    - a. Three-phase average current.
    - b. Three-phase total active power (kW).
    - c. Reactive power (kVAR).
    - d. Apparent power (kVA).
  - 5. Minimum and Maximum Values:
    - a. L-L and L-N voltages.
    - b. Current in each phase.
    - c. Power factor.
    - d. Active power total.
    - e. Reactive power total.
    - f. Apparent power total.
    - g. THD L-L and L-N voltages.
    - h. THD current in each phase.
    - i. Frequency.
- H. Power Demand, User Selectable:
- 1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
  - 2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
    - a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
    - b. Fixed block that calculates demand at end of the interval.
    - c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
  - 3. Demand Calculation Initiated by a Synchronization Signal:
    - a. Signal is a communication signal. Calculation must be configurable as either a block or rolling block calculation.
    - b. Provide for synchronizing the demand with the internal of this instrument.
- I. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.
- 1. Minimum and maximum of real-time RMS measurement.
  - 2. Energy.
  - 3. Demand values.
  - 4. Alarms, store a minimum of 14 parameters every 15 minutes for 90 days.

- J. Output Signals: Provide two mechanical relays, rated not less than 250 V(ac), 2 A resistive, and rated for 200,000 cycles or more. The relays must be user configurable in one of the following listed modes:
  - 1. Normal contact closure where the contacts change state for as long as the signal exists.
  - 2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
  - 3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.
- K. Meter Face:
  - 1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
  - 2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
  - 3. Provide for the reset of metered peak values.
- L. Capacities and Characteristics:
  - 1. Power Supply: Self powered
  - 2. Circuit Connections:
    - a. Voltage: Measurements auto ranging, 90 to 300 V(ac) L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance must be 2 megohm L-L or greater. Overload Tolerance: 1500 V(ac), RMS, continuously.
    - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
    - c. Frequency: 45 to 65 Hz.
    - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

## 2.4 MULTI CIRCUIT ENERGY METERS

- A. Multifunction Energy Meter: Separately or internally mounted, modular, permanently installed, solid-state, digital I/O instrument for energy metering and monitoring of multiple circuits; complying with UL 61010-1.
  - 1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
  - 2. Capable of supporting up to 28 three-phase meters.
- B. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- C. Accuracy: Comply with ANSI C12.20, Class 0.2.
- D. Communications:
  - 1. Integral ethernet to serial gateway
  - 2. One RS-485 serial port with Modbus RTU
  - 3. Two Ethernet ports capable of both Modbus TCP/IP and BACnet IP.

- E. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 128 samples per cycle, simultaneously on voltage and current channels of the meter.
- F. Meters:
  - 1. Instantaneous, real time RMS:
    - a. Current: Each phase, neutral and three-phase average.
    - b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
    - c. Active Power (kW): Each phase and three-phase total.
    - d. Apparent Power (kVA): Each phase and three-phase total.
    - e. Power Factor: Each phase and three-phase total.
  - 2. Energy: Accumulated
    - a. Active Energy (kWh): Per phase and Three-phase average.
- G. Capacities and Characteristics:
  - 1. Power Supply: Self Powered
  - 2. Circuit Connections:
    - a. Voltage: Measurement auto ranging, 90 to 300 V(ac) L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Overload Tolerance: 1500 V(ac), RMS, continuously.
    - b. Current: Connect to instrument grade low voltage current transformers (LVCT) with a metering range of 50A to 5,000A and a maximum lead length of 100-feet.
    - c. Frequency: 45 to 65 Hz.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Wiring Method: Install cables in raceways except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

- D. Wiring and Cabling Installation: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
- E. Raceways Installation: Comply with Section 260533 "Raceway and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

### 3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553, "Identification for Electrical Systems" and as noted below:
  - 1. Provide nameplate for each meter.

### 3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
- B. Field tests and inspections must be witnessed by Owner's Representative.
- C. Tests and Inspections
  - 1. Visual and Mechanical Inspections
    - a. Examine equipment nameplate data and confirm proper identification.
    - b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
    - c. Verify tightness of electrical connections.
    - d. Visually inspect cable placement, cable termination, grounding and bonding, and labeling of components.
    - e. Confirm and record settings for system configuration, CT and PT ratios, multipliers, communications and other specified parameters are in accordance with record drawings or customer supplied specifications.
  - 2. Electrical Tests
    - a. Verify meter accuracy is within manufacturer's published tolerances.
    - b. Calibrate meters in accordance with manufacturer's instructions.
    - c. Verify all instrument multipliers.
    - d. Verify integrity of current transformer circuits.
    - e. Confirm correct operation and setting of any auxiliary input/output features.
    - f. Verify proper system operation.
- D. Nonconforming Work: Wiring and cabling will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 260913

## SECTION 260923 - LIGHTING CONTROL DEVICES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description:

1. Section includes requirements for the provision of Lighting Controls including manufacturing, fabrication, configuration, and installation as required for the complete performance of the Work, as shown on the Drawings, as specified herein.
2. This work consists of providing all labor, materials, accessories, mounting hardware and equipment necessary for an operationally and aesthetically complete installation of all lighting controls.
3. Specifications and drawings are intended to convey all salient features, functions and characteristics of the lighting control devices only, and do not undertake to illustrate or set forth every item or detail necessary for the work. Minor details, not usually indicated on the drawings nor specified, but that are necessary for proper execution and completion of the lighting controls shall be included, the same as if they were herein specified or indicated on the drawings.

- B. Section Includes:

1. General lighting control devices
2. Digital lighting control devices
3. Lighting Control Relay panels
4. Lighting Control Panelboards
5. Lighting Contactor Cabinets
6. Electronic Digital Time Switches
7. Outdoor Photoelectric Switches
8. Emergency lighting control devices

- C. Related Requirements:

1. Refer to Section 260500, "Common Work Results for Electrical Systems" for requirements related to equipment supports.
2. Refer to Section 262726, "Wiring Devices" for requirements related to lighting snap switches and wall plates.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms

1. BAS: Building Automation System.

2. DDC: Direct Digital Controller/Direct Digital Control.
3. IP: Internet protocol.
4. NRTL: Nationally Recognized Testing Laboratory
5. SPD: Surge Protection Device

B. Definitions

1. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100 and ANSI/IES LS-1.
2. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
3. Zone: A light fixture or group of light fixtures controlled simultaneously as a single dimmer/relay/entity.
4. Occupancy Sensor: Motion sensing device programmed as automatic on and automatic off.
5. Vacancy Sensor: Motion sensing device programmed as manual on and automatic off.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA):
  - a. NECA NEIS 130, "Standard for Installing and Maintaining Wiring Devices"
2. Underwriters Laboratories, Inc. (UL):
  - a. UL 508, "Standard for Industrial Control Equipment."
  - b. UL 773, "Plug-in, Locking Photocontrols for Use with Area Lighting."
  - c. UL 773A, "Nonindustrial Photoelectric Switches for Lighting Control."
  - d. UL 916, "Standard for Energy Management Equipment Systems."
  - e. UL 917, "Clock Operated Switches."
  - f. UL 924, "Emergency Lighting and Power Equipment."
  - g. UL 1008, "Transfer Switch Equipment."
  - h. UL 1449, "Transient Voltage Surge Suppressors."
  - i. UL 2108, "Low-Voltage Lighting Systems."

#### 1.4 SUBMITTALS

A. Product Data: For each type of product indicated including physical data and electrical performance. Include data on features, accessories, finishes, and the following:

1. Physical description, including dimensions.
2. All available finishes and colors for each device and wall/cover plate shall be submitted to the Architect for selection during review.
3. Control type: 0-10V, DMX, bi-level, etc.
4. Sample Warranty.

B. Shop Drawings: Show installation details for occupancy, vacancy, light-level sensors, and digital control devices.

1. Lighting floor plan showing location, orientation, and coverage area of each wall and ceiling mounted sensor.
2. Interconnection diagrams showing field-installed wiring.
3. Riser diagrams indicating device network and cabling types.
4. Include systems descriptions, set points, and controls settings and adjustment.



- C. Manufacturer's Installation Instructions: Include for manufactured components.
- D. Control Schedules: After confirming with owner, list operating hours for each day of the week, include observed holidays.
- E. Qualification Data: For Start-Up Field Technician
- F. Closeout Submittals
  - 1. Operation and Maintenance Data: For each type of product to include in operation and maintenance manuals. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Description of operation and servicing procedures.
    - b. Technical support contact
    - c. List of components.
    - d. Recommended spare parts.
    - e. Programming instructions and system operation procedures.
    - f. Include interconnection wiring diagrams complete field installed system with identified and numbered, system components and devices.
    - g. Include operation and maintenance manuals for equipment and devices, including sensors, power supplies, and other equipment furnished.
    - h. Provide detailed set-up information for furnished equipment, indicating required initial configuration switch settings, jumper positions, to facilitate equipment replacement.
    - i. Include device calibration settings after system programming and start-up with manufacturer's representative.
  - 2. Software and Firmware Operational Documentation:
    - a. Software operating and upgrade manuals.
    - b. Program Software Backup: On USB media. Provide names, versions, and website addresses for locations of installed software.
    - c. Device address list.
    - d. Printout of software application and graphic screens.

#### 1.5 MAINTENANCE MATERIAL

- A. Extra Stock Material: Provide one (1) of each type of sensor, switch, dimmer, power pack, and emergency lighting control device installed. Package with protective covering for storage and identified with labels describing contents.
- B. Keys and Special Tools: Provide one extra set for access to locked or tamperproof enclosures.

#### 1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
  - 1. Manufacturer must maintain an authorized service organization within 100 miles of the project location that stocks a full complement of parts for all equipment specified in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.
  - 2. Provide toll free technical telephone support.

B. Installer Qualifications:

1. An employer of workers qualified and trained in electrical safety as required by NFPA 70E.

C. Start-Up Field Technician Qualifications:

1. Minimum experience of 2 years training in the electrical/electronic field.
2. Certified by the manufacturer on the system installed.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer instructions for storage of equipment and devices to prevent damage from dirt, moisture, or other environmental concerns.

1.8 COORDINATION

- A. Preinstallation Conference: Arrange a pre-installation conference between all applicable subcontractors and architect/engineer prior to the installation of rough ins for the lighting controls.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, speakers, fire alarm, HVAC equipment, fire-suppression system, and partition assemblies.
- C. Coordinate protocol and interface points of lighting control devices with temperature controls (BAS/DDC) specified in Division 23.
- D. Product procurement and coordination:
1. Order products according to application.
  2. Confirm the proper and complete catalog number with distributor and agent.
  3. Provide additional parts and pieces required to complete the installation in the location and manner intended by the design.
  4. Confirm voltages.
- E. Contractor shall coordinate with Vendors and other trades, in advance of installation work, to define all infrastructure and installation requirements. Contractor shall coordinate all infrastructure requirements with all approved lighting control devices prior to infrastructure installation. This includes, but not limited to, appropriately sized, positioned, and located junction boxes, structural supports, feeds, power conduits, control conduits, and remote code-compliant power-supply enclosures.

1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace lighting controls, finishes, wiring, cabling and all of its components that fail in materials or workmanship within 5 years from date of Substantial Completion.

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## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70, as well as applicable ANSI, IEC standards, and FCC regulations.
- C. Comply with CFR Title 47, Part 15, Subparts A and B, for Class A digital devices.
- D. Devices shall be in accordance with NFPA 70, NEMA, and UL listed and labeled.
- E. RoHS compliant.
- F. Devices located in above ceilings shall be plenum rated.
- G. Power failure: Incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and parameters saved in protected memory shall not be lost and should restore system to its last operating state without requiring user input.
- H. Failsafe operation: If automatic switching device loses power, device will latch to closed "ON" position.
- I. Components shall be designed and tested to withstand discharges without impairment of performance when subjected to discharges of 15,000 volts per IEC 801-2.
- J. Products tested in identical manner, complaint to NEMA WD 7 -2011 Occupancy Motion Sensors Standards.
- K. Voltage: 120/277VAC unless noted otherwise
- L. Line-Voltage Surge Protection: Include in all 120- and 277-V solid-state equipment. Comply with UL 1449 and with ANSI C62.41 for Category A locations.
- M. Refer to Section 262726 "Wiring Devices" for device and faceplate colors.
- N. Standard Operating Range: 32 to 120 deg F, up to 90 percent relative humidity, non-condensing, unless noted otherwise.
- O. Minimum load rating: 800W at 120VAC and 1200W at 277VAC.
- P. Provide all control devices with LED status indicator.
- Q. Minimum Occupancy and Vacancy Sensor Coverage Radius:
  - 1. Wall Switch: 35 ft for large motion, 20 ft for small motion.
  - 2. Ceiling, 360 deg, Standard Range: 12 ft radius for small motion.
  - 3. Ceiling, 360 deg, Extended Range: 28 ft radius for large motion.
  - 4. Corner, 120 deg: 40 ft for large motion.
  - 5. Hallway: 100 ft for large motion.
  - 6. High Bay, 360 deg: 20 ft radius at 15 ft mounting height for large motion

## 2.2 GENERAL LIGHTING CONTROL DEVICES

- A. Basis of Design: Subject to compliance with requirements, provide products indicated on Drawings or equivalent by one of the following:
1. Acuity Sensorswitch
  2. Hubbell
  3. Leviton
  4. Lutron
  5. Wattstopper
- B. Wall Switch Occupancy and Vacancy Sensors: Decora style sensor with on/off switch(es) for mounting in a single gang switchbox.
1. Programmable Automatic On and Manual On Operating Modes.
  2. Time Delay for Automatic Off: Adjustable up to 20 minutes.
  3. Programmable sensitivity settings.
  4. Sensing Technology: Dual technology, PIR and Ultrasonic or Microphonics unless noted otherwise.
  5. Noise filtering to eliminate false triggers.
  6. Vandal resistant lens
  7. Multi-Way: Multi-way: Capable of operation in 3-way application where indicated.
  8. Dimming: Provide 0-10V dimming output where indicated.
  9. Dual Relay: Where independent control of two loads is required, provide unit with two isolated relays and override switches, capable of independent operating modes and time delays.
- C. Line Voltage Occupancy Sensors: Self-contained occupancy sensor with integral power supply and relay suitable for mounting to a standard outlet box in ceiling and wall mounted applications
1. Automatic On operation.
  2. Time delay for Automatic Off: Adjustable up to 20 minutes.
  3. Sensing Technology: Dual technology, PIR and Ultrasonic or Microphonics unless noted otherwise.
  4. Dual Relay: Where independent control of two loads is required, provide unit with two isolated relays and override switches, capable of independent operating modes and time delays.
- D. Low Voltage Occupancy, Vacancy Sensors, Daylight Sensors, Power Packs, and Low Voltage Wall Stations
1. Programmable Automatic On and Manual On Operating Modes.
  2. Time Delay for Automatic Off: Adjustable up to 20 minutes.
  3. Sensing Technology: Dual technology, PIR and Ultrasonic unless noted otherwise.
  4. Noise filtering to eliminate false triggers.
  5. Isolated Relay: Low voltage relay with N.O. and N.C. outputs to indicate occupancy status for HVAC interface with BAS/DDC system.
  6. Power Packs/Load Controllers: Self-contained power supply with relay module capable of switching 20-amp load.
    - a. Class 2, 24VDC output for powering low voltage sensors.
    - b. UL 2043 Plenum Rated.

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- c. Threaded 1/2-inch nipple, suitable for mounting inside or outside a junction box.
    - 7. Wall stations: Low voltage, decorator style, with single or multiple pushbuttons for interface with power packs and sensors.
      - a. Multi-way: Capable of operation in 3-way application.
      - b. Manual Dimming: Provide 0-10V dimming output where indicated.
    - 8. Low Voltage Indoor Daylight Sensors: Low voltage, ceiling mounted photosensor that detects changes in light levels.
      - a. Suitable for interface with an occupancy/vacancy sensor, power pack, or another field device.
      - b. Closed loop device: measures both daylight contribution and controlled electric light contribution.
      - c. Open Loop device: measures only daylight contribution.
      - d. Desired task level illuminance: Auto calibrating, programmable, with daytime and nighttime on/off setpoints and a dead band to prevent light from cycling.
      - e. Auto Dimming: Provide 0-10V dimming output for automatic dimming control of luminaires.
  - E. Interval Timer Light Switch: Combination countdown timer and conventional switch lighting control unit, switchbox mounted, decorator style.
    - 1. On/Off Switch with Status LED.
    - 2. Adjustable preset intervals.
    - 3. Warning: Audible and/or flash timeout warning.
  - F. Wallbox Dimmer Switches
    - 1. Single gang decorator style, suitable for full range continuous variable control of luminaire light intensity.
    - 2. Comply with UL 1472.
    - 3. Preset slide style dimming control with a mechanical air-gap switch to totally disconnect power from the load when in the off position.
    - 4. Compatible with luminaire ballast or driver.
- 2.3 DIGITAL LIGHTING CONTROL DEVICES
- A. Manufacturers: Subject to compliance with requirements, provide products indicated on drawings or equivalent by one of the following:
    - 1. Acuity nLight
    - 2. Crestron Zum
    - 3. Hubbell NX
    - 4. Wattstopper DLM
  - B. Description: Intelligent control devices capable of operating in standalone control zones or in a networked configuration for remote, time-based, and global operation with inputs from digital signal sources and remote configuration and monitoring through a software interface.

- C. System Architecture:
1. Free topology plug-in wiring with green Cat 5e network cabling for power and data between control devices, switches, and sensors.
  2. Self-configuring, digitally addressable control devices.
  3. Any combination of inputs shall be programmable to any number of control devices.
  4. Automatic configuration and connection of room loads to the connected control devices in the space without commissioning or the use of any tools.
  5. Units shall not have any dip switches or potentiometers for field settings.
- D. Sensors, power packs, and wall stations shall be interconnected through RJ-45 ports and comply with General Requirements section specified herein.
- E. System Accessories: Provide the following accessories as required for implementation of the control intent illustrated on the drawings.
1. Digital Plug Load Controllers: Self-configuring, single relay, 20A, 120V, on/off control.
  2. Daylight Sensors: Shall be digital and comply with General Requirements section specified herein.
    - a. Daylight sensor groupings: The set of zones that are controlled by a given daylight sensor shall be configurable through associated lighting relay room controller and shall not require manual wiring to modify.
    - b. Daylight sensor settings: Settings associated with a given daylight sensor shall be adjustable through associated lighting relay room controller and shall not require any physical adjustment to the sensor itself.
  3. Touchscreen: Customizable LCD capacitive touchscreen for on/off, dimming, zone, and scene control.
  4. Wireless Configuration Tools: Handheld remote for device setting programming, two-way IR communication.
  5. I/O Module: Input / Output device. 24VDC relay with normally open, normally closed, and common outputs to indicate occupancy or lighting status to third party systems such as a BAS. Four input terminals for maintained or momentary switch closure inputs.
  6. BACnet Appliance: Provides BACnet MS/TP digital networked communication between rooms, panels, Gateway, or BAS and automatically creates BACnet objects representative of connected devices.
  7. IP Gateway: BACnet to ethernet interface to allow web browser-based user interface for system control, scheduling, power monitoring, room device parameter administration and reporting.
  8. Programming and Configuration Software: PC-native application capable of accessing DLM control parameters within a room, for the local network, via a USB adapter, or globally, for many segment networks simultaneously, via BACnet/IP communication.
- F. Sequence Control and Override: Networked systems utilizing astronomical or time of day controls shall comply with the following.
1. Override control must allow any relay connected to it to be switched on or off by a manual switch or by an automatic switch, such as a sensor. Provide 2-hour override unless otherwise noted.
  2. Override control "blink warning" must warn occupants approximately five minutes before actuating the off sequence. Does not apply to exterior lighting.

3. Activity log, storing previous relay operation, including the time and cause of the change of status.

## 2.4 LIGHTING CONTROL RELAY PANELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Douglas Lighting Controls
  2. Leviton Greenmax
  3. Lighting Controls & Design (LC&D)
  4. Lyntec
  5. Wattstopper Lighting Integrator
- B. Description: Lighting control panel using mechanically latched relays to control lighting and appliances based on inputs from sensors, switches, or other sources along with zone based timed overrides and blink warnings. Capable of operation in a standalone application or interconnected with digital communications to operate multiple panels as a single system.
  1. Pre-assembled steel enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit. Comply with UL 508.
  2. A vertical barrier separating branch circuits from control wiring.
  3. Suitable for surface or flush mounting with a hinged locking door assembly.
  4. Relay capacity and configuration as required to accommodate switched zones shown on drawings plus 20 percent spare capacity.
  5. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.
- C. Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.
  1. Native Ethernet Communications: Comply with TCP/IP protocol. Provide for programming of all control functions of lighting control panels including timing, sequencing, and overriding.
  2. Integral keypad, USB port, and LCD digital-display for local programming
  3. Nonvolatile memory must retain all setup configurations. After a power failure, the controller must automatically reboot and return to normal system operation, including accurate time of day and date.
  4. Web Server: Display control, setup, and diagnostic information over a standard Web-enabled server for displaying information over a standard browser.
  5. Timing Unit
    - a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
    - b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
    - c. Four independent schedules, each having 24 time periods.
    - d. Schedule periods settable to the minute.
    - e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
    - f. 10 special date periods.

6. Sequence Control and Override:

- a. Automatic sequenced on and off switching of individual or groups of relays at times set at the timing unit, allowing timed overrides from external switches.
- b. Sequencing control must operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
- c. Override control must allow any relay connected to it to be switched on or off by a manual switch or by an automatic switch, such as a sensor. Provide 2-hour override unless otherwise noted.
- d. Override control "blink warning" must warn occupants approximately five minutes before actuating the off sequence. Does not apply to exterior lighting.
- e. Activity log, storing previous relay operation, including the time and cause of the change of status.

D. Relays

1. Electrically operated, mechanically held, minimum 20 A rating at 120/277 VAC for single pole switches and 208/240/480VAC for double pole switches.
2. Integral manual ON/OFF switch with visual display of switch state.
3. Suitable for control of incandescent, fluorescent, LED, and HID loads.
4. Short-circuit current rating must not be less than available fault current as indicated in power system study.

E. Integral Power Supply: NFPA 70, Class 2, sized for connected equipment, plus 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, control-voltage inputs, and any field-installed sensors.

F. Push-Button and Key Operated Wall Station Switches: Modular, momentary contact or digital, for operating one or more relays and to override automatic controls.

G. Sensors and photocells: Powered from the lighting control relay panel, and signal compatible with the relay panel control unit. Comply with General Requirements section specified herein.

## 2.5 LIGHTING CONTACTOR CABINETS

A. Basis of Design: Subject to compliance with requirements, provide product indicated or equivalent product by one of the following:

1. Asco
2. Eaton
3. Square D

B. Description: Factory-wired and tested, lighting control cabinet with contactors, controls, and accessories in single enclosure.



- C. Contactors: Electrically operated, dual acting single solenoid mechanism, mechanically held in both open and closed positions, combination-type remote control lighting contactors, complying with NEMA ICS 2 and UL 508.
  - 1. Current Rating for Switching: 30A up to 600VAC.
  - 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
  - 3. Visual position indicator.
  - 4. Control Coil Voltage: Match control power source.
  - 5. Provide contactor capacity and configuration as required to accommodate switched zones shown on drawings plus 4 spares.
- D. Control Modules: Solid State interface module, start/stop, two-wire, or three-wire control, mounted directly to contactors.
  - 1. Integral auxiliary SPDT contacts to indicate position of the contactor.
  - 2. Provide solid state control modules as necessary to interface with BAS/DDC systems, timers, photoelectric switches, and similar control devices as required by lighting control zones and sequences.
- E. Enclosure: Comply with NEMA 250, Steel, NEMA 1 enclosure with hinged lockable cover cabinet enclosure sized as required for components, unless otherwise indicated. Mount switches and indicating lights required on front of enclosure. Install terminal strips for connection of all external control wiring connections. Surface or flush mounted as shown on drawings.
- F. Provide the following integral control and indicating devices:
  - 1. Hand-off-auto (HOA) selector switch, of the heavy-duty "oil-tight", maintained-contact type, mounted on the front cover with legend plate.
  - 2. Auxiliary SPDT contacts to indicate position of HOA switch.
  - 3. Auxiliary relay to convert maintained-contact type control circuit to momentary-contact type control circuit necessary for contactor control.
  - 4. Control transformer with primary voltage as indicated and 120-volt, single phase, 60 hertz secondary including fuse and fuse holder.
  - 5. Green and Red pilot lights to indicate "Power ON" and "Power OFF" condition. Mount on front cover with legend plate.
  - 6. Photocell: Compatible with control voltage and complies with Outdoor Photoelectric Switches section specified herein.
  - 7. Interface with BAS/DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.
    - a. Monitoring: Contactor On-off status, HOA switch On, HOA switch Auto.
    - b. Control: Contactor On-off operation.

## 2.6 ELECTRONIC DIGITAL TIME SWITCHES

- A. Basis of Design: Subject to compliance with requirements, provide product indicated or equivalent product by one of the following:
  - 1. Intermatic
  - 2. Tork

- B. Description: Electronic, solid-state programmable units with alphanumeric display complying with UL 916 and UL 917.
1. Contact capacity and configuration as required to accommodate switched zones and loads shown on drawings.
  2. Contact Rating: 30-A, 120/277-VAC.
  3. Operating Temperature: -40 to 155 deg F.
  4. Enclosure: Steel, NEMA 3R outdoor, lockable.
  5. Schedule: Astronomic 7-day/365-day dusk to dawn scheduling with up to 48 on and 48 off events per week and an annual holiday schedule that overrides the weekly operation on holidays.
  6. Automatic daylight savings time changeover.
  7. Adjustable switching configurations for simultaneous, independent, or pulse control of contacts.
  8. 2-hour override buttons.
  9. Backup power: Minimum 100-hour time and date retention.
  10. Nonvolatile memory, to maintain programming after power loss.
  11. USB connection for uploading, downloading and transferring of programs

## 2.7 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturer: Subject to compliance with requirements, provide product by one of the following:
1. Intermatic
  2. Tork
  3. Precision
- B. Description: Solid state, 120-277VAC, with SPST dry contacts rated for 1800-VA, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
  2. Time Delay: Fifteen second minimum, to prevent false operation.
  3. Surge Protection: Metal-oxide varistor.
  4. Mounting: Base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
  5. Enclosure: Outdoor weathertight housing, resistant to high temperatures, equipped with sun-glare shield, ice preventer, and directional lens to prevent fixed light sources from causing turn-off.
  6. Failure Mode: Luminaire stays ON.

## 2.8 CONDUCTORS AND CABLES

- A. Wiring to supply side of remote-control power sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519, Low-Voltage Electrical Power Conductors and Cables

- B. Low-voltage control cable for 0-10VDC dimming: Manufacturer's standard multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG, plenum rated unless otherwise recommended by the manufacturer.
- C. Class 1 and 2 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 14 AWG, plenum rated unless otherwise recommended by the manufacturer.
- D. UTP cabling: Unshielded, plenum rated, Cat5e twisted-pair cable. Comply with lighting control system manufacturer's recommendations.

## 2.9 SOURCE QUALITY CONTROL

- A. Factory Tests and Inspections: Perform full-function testing on 100 percent of all system components and panel assemblies at the factory prior to delivery.
- B. System control components shall be certified by the manufacturer to have been designed, manufactured and tested for interoperability.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine lighting control devices and equipment before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls, ceilings, and other mounting surfaces for suitable conditions where lighting control devices and equipment will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install lighting controls and equipment in accordance with manufacturer's written instructions, applicable requirements of NEC, and NECA 500 and 501.
- B. Electrical installations shall conform to and meet IEEE C2, NFPA 70, and to the requirements specified herein.
- C. Devices and Equipment shall be installed and programmed to meet the control intent.
- D. Device Installation:
  - 1. Comply with Section 262726 "Wiring Devices" for wall mounted device and faceplate installation requirements.
  - 2. Install in a single box and provide a single cover plate where two or more devices are shown adjacent on plans. Provide voltage barrier where required.
  - 3. Verify door swings with door frame installed prior to rough-in for switches and sensors. Locate switches on latch side of door.
  - 4. Device Orientation: Install switches and dimmers with the "OFF" position down.

E. Panels and Cabinets:

1. Install panels and cabinets in accordance with NECA 407.
2. Mount top of trim no greater than 90-inches above finished floor unless otherwise indicated.
3. Mount panel cabinet plumb and rigid without distortion of box.
4. Install filler plates in unused spaces.

F. Conductors/Wiring:

1. Wiring Methods: Comply with Section 260519, Low-Voltage Electrical Power Conductors and Cables.
2. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.
3. Voltage Drop: Adjust conductors and conduit sizes accordingly based on actual field installed conditions.
4. Where the total conductor length for 0-10VDC dimming applications exceeds the values below, adjust conductor size as noted.
  - a. Conductor lengths up to 300 feet: #18 AWG minimum.
  - b. Conductor lengths between 300 feet and 430 feet: #16 AWG minimum.
  - c. Conductor lengths between 430 feet and 690 feet: #14 AWG minimum.
  - d. Conductor lengths between 690 feet and 1100 feet: #12 AWG minimum.
  - e. Conductor lengths between 1100 feet and 1750 feet: #10 AWG minimum.
5. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
7. Provide plenum-rated cable, where installed exposed or in open cable tray, within environmental airspaces, including plenum ceilings.

G. Lighting Controllers/Power Packs:

1. Room controllers shall be surface mounted in accessible ceiling space above entry door. Install no higher than 6" above accessible ceiling.
2. Install controllers/power packs on the unswitched line side of local switches to keep sensors powered at all times.
3. Provide controllers/power packs(s) for each room/area/control zone for a working system.
4. Note all power pack locations and branch circuiting on as-built record drawings.

H. Lighting Contactors

1. Install lighting contactors as indicated on plan. Install at accessible locations.
2. Mount contactors in a manner to eliminate structure-borne vibration

I. Occupancy and Vacancy Sensors

1. Provide quantity of sensors indicated as a minimum. Provide additional units to give full coverage over controlled area. Provide full coverage for hand and arm motion detection in office, classroom, and administration type areas and walking motion for storage rooms and hallways.

2. Install wallbox sensors at switch height indicated on drawings,
3. Install wall sensors without manual switches at 8 ft above finished floor unless otherwise noted on drawings.
4. Install ceiling mounted sensors at locations indicated on manufacturer's shop drawings. Sensor manufacturer shall provide quantity of sensors as required to provide complete coverage for rooms.
5. Locate sensors such that motion through open doors will not falsely activate sensors.
6. Do not locate ultrasonic sensors within six feet of supply air diffusers.
7. Locate infrared sensors to avoid obstructions.

### 3.3 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
  1. Identify all components and power and control wiring.
  2. Label time switches and contactors with a unique designation.
  3. Provide directories inside relay panels and contactor cabinets that identify each relay and the associated control zone.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform system start-up, functional testing, and inspection of components, assemblies, and equipment installations, including connections.
- B. Visual and Mechanical Inspections:
  1. Upon completion of installation, verify that equipment is properly installed, connected, and adjusted.
  2. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.
- C. System Start-up:
  1. Complete installation and startup checks according to manufacturer's written instructions.
  2. Confirm layout and location of sensors with manufacturer's recommendations to achieve proper coverage of indicated areas. Provide additional sensors and control units as required to achieve complete minor motion coverage of the space indicated. Provide customizable sensor masks to block off unwanted viewing areas.
  3. Confirm control schedules with owner including operating hours for each day of the week and holiday schedules. Submit to design team for approval.
  4. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.
- D. System Functional Tests: After installing all control devices, automatic time switches, and sensors, and after electrical circuitry has been energized, test systems for compliance with approved sequences in accordance with energy code requirements.
  1. Adjust time delays, trim settings, dead bands, and scene settings.

2. Owner and architect/engineer shall be present during adjustment of scene settings. Exterior scenes shall be adjusted during non-daylit hours.
3. Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
4. Include testing of devices under conditions that simulate actual operational conditions including occupied and unoccupied states.
5. Verify all emergency lighting functions upon loss of power.
6. Record all control settings, operations, cues, and functional observations.

E. Nonconforming Work:

1. Lighting control devices and equipment will be considered defective if it does not pass tests and inspections.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace defective units and retest.
3. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

F. Prepare test and inspection reports.

### 3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.
- B. The lighting and lighting controls systems shall be synchronized and fully operable to address the lighting operation in a complete and code-compliant manner.
- C. All ladders, scaffolds, lifts, gloves, cleaning cloths, access/adjustment tools, etc. required for aiming and adjusting lighting controls shall be furnished by the Contractor.

### 3.6 PROTECTION

- A. Install lighting control devices after all wall preparation, including painting, is complete.
- B. Replace all devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
- C. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
- D. Do not remove surface protection, such as plastic film and smudge covers, until final cleaning has been completed.

### 3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's facility management and maintenance personnel, and selected Owner representatives. as specified below:
  1. Train Owner's maintenance personnel on troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of four (4) hours training.

2. Training Aid: Use the approved final version of maintenance manuals as a training aid.
3. Training shall include, but not be limited to, overview, adjustment, operation, use, maintenance, and demonstration of the lighting control system.

B. Software Service Agreement

1. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
  - a. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

END OF SECTION 260923

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## SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

#### 1.2 SUMMARY

- A. Description: Section includes requirements for the provision of Low-Voltage, dry type distribution transformers including manufacturing, fabrication, configuration and installation as required for the complete performance of the Work, as shown on the Drawings, as specified herein.
- B. Section includes distribution, energy efficient, dry-type transformers with a nominal primary and secondary rating of 600 V and less.
- C. Related Requirements:
  - 1. Refer to Section 260500 “Common Work Results for Electrical Systems” for requirements related to equipment bases, supports, and vibration pads.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. DOE: Department of Energy
  - 2. FCAN: Full Capacity Above Normal
  - 3. FCBN: Full Capacity Below Normal
  - 4. XFMR: Transformer
- B. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. National Electrical Contractors Association (NECA)
    - a. NECA 409, “Standard for Installing and Maintaining Dry-Type Transformers”.
  - 2. National Electrical Manufacturers Association (NEMA)
    - a. NEMA ST20, “Dry Type Transformers for General Applications”.
  - 3. Underwriters Laboratories Inc (UL)
    - a. UL 1561, “Dry-Type General Purpose and Power Transformers”.
  - 4. Federal Regulations and Policies

- a. DOE 10 CFR Part 429, "Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment".
- b. DOE 10 CFR Part 431, "Energy Efficient Program for Certain Commercial and Industrial Equipment".

#### 1.4 SEQUENCING

- A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

#### 1.5 SUBMITTALS

- A. Product Data: For each type of product. Include the following:
  - 1. Basic Performance characteristics including insulation class, temperature rise, core and coil materials, impedances & audible noise level, unit weight, and inrush data expressed in either Amperes RMS or Times Rated input current.
  - 2. Efficiency Data per NEMA ST20 and 10 CFR Part 431 at 35% loading point.
  - 3. No load and full load losses calculated per NEMA ST20 test methods.
  - 4. Efficiency levels at 25%, 50%, 75%, and 100% load points.
- B. Shop Drawings: For each product type.
  - 1. Enclosure dimensions and clearances
  - 2. Wiring Diagrams: Power, signal, and control wiring.
  - 3. Wire Bending Dimensions
  - 4. Location for Ground Lug Provisions
  - 5. Factory provided mounting brackets
  - 6. Field installed accessories.
- C. Field quality-control test reports.
- D. Closeout Submittals
  - 1. Provide Operation and Maintenance Data for transformers to include in operation and maintenance manuals.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Remove and replace access fencing, doors, lift-out panels, and structures as required to provide pathway for moving transformers into place.
- B. Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental concerns.

## 1.7 COORDINATION

- A. Coordinate size and location of concrete bases with dimensions of transformer provided.
- B. Coordinate installation of wall and ceiling mounting hardware and structural supports with transformer provided.
- C. Distribution equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.
- D. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access and replacement working space requirements of the NEC and Owner.
- E. Conduct and submit results of power system studies before submitting Product Data and Shop Drawings for electrical equipment.
- F. Coordinate inrush current values of transformer provided with overcurrent protection device settings as described in Section 260573, "Power System Studies". Adjust overcurrent protection device size, settings, and feeder size to eliminate nuisance operation in response to the actual transformer inrush current.

## 1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace transformers, finishes, controls, wiring, and all of its components that fail in materials or workmanship within 12 months from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB/General Electric.
  - 2. Eaton.
  - 3. Siemens.
  - 4. Square D.
- B. Source Limitations: Obtain transformers and all other electrical distribution equipment through one source from a single manufacturer.

## 2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70, NEMA ST 20, and list and label as complying with UL 1561.
- C. Comply with (DOE) 10 CFR 431 for minimum energy efficiency levels. Transformers shall bear the UL Energy Efficiency Verification Mark to confirm that the unit meets minimum efficiency levels.
- D. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- E. Phase, kVA Ratings, and Primary and Secondary Voltages: as indicated on drawings.
- F. Cores: Grain-oriented, non-aging silicon steel with high permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating.
  - 1. One leg per phase.
  - 2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
  - 3. Visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
  - 4. Cores shall be clamped with structural angles and bolted to the enclosure to prevent damage during shipment or rough handling.
- G. Coils: Continuous windings without splices except for taps. Coils shall have a final wrap of electrical insulating material designed to prevent injury to the coil wire.
  - 1. Coil Material: Aluminum.
  - 2. Internal Coil Connections: Brazed or pressure type.
  - 3. Terminal Connections: Welded.
- H. Insulation Class: Minimum 220 deg C, UL-component-recognized insulation system.
  - 1. Temperature Rise: 115 deg C unless noted otherwise.
  - 2. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635
  - 3. Wire left bare will not be accepted, all conductors must have insulation material.
- I. Enclosure: Ventilated
  - 1. NEMA 250, Type 2 unless otherwise required by environmental conditions. Provide weathershield for ventilation openings where located outdoors.
  - 2. Heavy gauge steel construction.
  - 3. The core and coil unit shall be completely isolated from the enclosure by means of a vibration isolating system and shall be so designed as to provide for continual securement of the core and coil unit to the enclosure.
  - 4. Core and coil shall be encapsulated within non-hygroscopic thermosetting varnish, sealing out moisture and air.
  - 5. Wiring Compartment: Sized for conduit entry and wiring installation.

6. Minimum clearances from ventilated openings to obstructions shall be indicated on the nameplate and not exceed 6-inches.
7. The maximum top of case temperature shall not exceed 35 deg C above 40 deg C ambient.
8. Finish: Gray weather resistant baked enamel, complying with NEMA 250.

J. Taps:

1. Three-phase transformers rated 15 kVA and larger shall be provided with six 2-1/2% full capacity taps, two above and four below rated primary voltage.
2. Three-phase transformers rated below 15kVA shall be provided with two 5% full capacity taps below rated primary voltage.

K. Grounding: Provide ground bar installed on the inside of the transformer enclosure.

L. Wall and Ceiling Brackets: Manufacturer's standard brackets.

M. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

N. Terminations: Mechanical Lugs listed to accept specified wiring method, conductor size, and temperature rating.

## 2.3 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91 and IEEE C57.12.91.

1. Ratio tests at the rated voltage connection and at all tap connections.
2. Polarity and phase relation tests on the rated voltage connection
3. Applied potential tests
4. Induced potential test
5. No-load and excitation current at rated voltage on the rated voltage connection

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on equipment for this Project.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances and equipment operation required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install transformers level and plumb with vibration dampening supports.
  - 1. Provide wall and ceiling mounted transformers with brackets fabricated by transformer manufacturer.
  - 2. Coordinate installation of structural steel supports with actual transformer provided.
- B. Construct concrete bases and anchor floor-mounted transformers according to manufacturer's written instructions.
- C. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- D. Remove shipping bolts, blocking, and wedges.

### 3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Provide flexible connections at all conduit and conductor terminations and supports according to Section 260533, "Raceways and Boxes for Electrical Systems" and Section 260500, "Common Work Results for Electrical Systems" to eliminate sound and vibration transmission to the building structure.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- E. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

### 3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553, "Identification for Electrical Systems".

1. Where primary disconnecting means is not provided within sight of transformer, identify transformer with equipment designation and location of remote lockable disconnecting means by permanent nameplate.
2. All distribution equipment shall be shipped from the manufacturer with factory-applied warning labels affixed to the outside front of the equipment (as it will be installed per the plans). All labeling shall be in compliance with NFPA 70 requirements.
3. Labels affixed to equipment by the equipment manufacturer shall comply with drawing and specification labeling requirements or shall be omitted by the manufacturer and field-installed by the Contractor. Labels which are factory-installed and not in compliance shall be removed and replaced and equipment enclosures refinished or replaced by the manufacturer to repair finish.

### 3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections: Perform the following tests and inspections. Certify compliance with test parameters.
  1. Visual and Mechanical Inspection
    - a. Document equipment nameplate data on the test report. Verify that transformer nameplate ratings are in accordance with drawings.
    - b. Inspect the physical and mechanical condition of the equipment.
    - c. Inspect anchorage, alignment, and grounding.
    - d. Verify that resilient mounts are free and that any shipping brackets have been removed.
    - e. Inspect bolted electrical connections for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
  2. Electrical Tests
    - a. Perform insulation-resistance tests. Measurements shall be made from winding-to-winding and each winding-to-ground. Test voltages and minimum resistance shall be in accordance with manufacturer's published data.
    - b. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.
- B. Test and Inspection Reports: Prepare a written report to certify compliance with test parameters and record the following:
  1. Test procedures used.
  2. Results that comply with requirements.
  3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- C. Products will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.
- D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.6 CLEANING:

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200



## SECTION 262413 - SWITCHBOARDS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for low voltage switchboards as required for the complete performance of the Work, as shown on the Drawings as specified herein.
- B. Section Includes:
  - 1. Service and distribution switchboards rated 600 V and less.
  - 2. Disconnecting and overcurrent protective devices.
  - 3. Instrumentation.
  - 4. Accessory components and features.
  - 5. Identification.
- C. Related Requirements:
  - 1. Refer to Section 260500, "Common Work Results for Electrical Systems" for requirements related to equipment pads.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. SPD: Surge Protective Device
  - 2. SWBD: Switchboard
- B. Definitions:
  - 1. Switchboard: A large single panel, frame, or assembly of panels on which are mounted switches, over-current, and other protective devices, buses, and instruments.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. National Electrical Contractors Association (NECA):
    - a. NECA 400, "Standard for Installing and Maintaining Switchboards"

2. National Electrical Manufacturers Association (NEMA):
  - a. NEMA PB 2, "Deadfront Distribution Switchboards."
  - b. NEMA PB 2.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less."
3. Underwriter Laboratories (UL):
  - a. UL 50, "Enclosures for Electrical Equipment, Non-Environmental Considerations."
  - b. UL 489, "Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures."
  - c. UL 891, "Standard for Switchboards"

#### 1.4 SEQUENCING

- A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

#### 1.5 SUBMITTALS

- A. Product Data: For each Switchboard.
  1. Include materials, switching and overcurrent protective device, ground-fault protector, arc energy reduction switches, accessories, and components.
  2. Include manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each Switchboard and related equipment.
  1. Include dimensioned plans, front and side elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
  2. Include conduit entrance locations and requirements; nameplate legends; one-line riser diagrams; equipment schedule; and switchboard instrument details.
  3. Detail enclosure types for types other than NEMA 250, Type 1.
  4. Detail bus configuration, current, and voltage ratings.
  5. Detail short-circuits current rating of Switchboards and overcurrent protective devices.
  6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  7. Include diagram and details of proposed mimic bus.
  8. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Field Quality-Control Reports:
  1. Test procedures used.
  2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Closeout Submittals

1. Operation and Maintenance Data: For Switchboards and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
  - a. Routine maintenance requirements for switchboards and all installed components.
  - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - c. Time-current coordination curves for each type and rating of overcurrent protective device included in Switchboards.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Minimum of five years of successful installation experience with projects utilizing switchboards similar in type and scope to that required for this Project.
2. An employer of qualified workers as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver Switchboards in sections or lengths that can be moved past obstructions in delivery path. Remove and replace access fencing, doors, lift-out panels, and structures as required to provide pathway for moving switchboards into place.
- B. Handle and prepare Switchboards for installation according to NECA 400 and NEMA PB 2.1. Lift only by lifting means provided for this express purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.
- C. Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental concerns.

1.8 COORDINATION

- A. Coordinate layout and installation of Switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with dimensions of actual equipment provided.
- C. Distribution equipment sizes and equipment layouts shown on drawings shall be considered the basis of design. Equipment sizes vary by manufacturer. If the proposed equipment is physically

larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.

- D. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access, and working space requirements of the NEC and Owner.

## 1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboards, circuit breakers, finishes, controls, wiring, and all of its components that fail in materials or workmanship within 12 months from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB.
  - 2. Eaton.
  - 3. Siemens.
  - 4. Square D.
- B. Source Limitations: Obtain switchboards, overcurrent protection devices, and all other electrical distribution equipment through one source from a single manufacturer.

### 2.2 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NEMA PB 2, NFPA 70, and UL 891.
- C. Front-Connected, Front-Accessible Switchboards unless otherwise indicated:
  - 1. Main Devices: Fixed, individually mounted unless otherwise indicated.
  - 2. Branch Devices: Panel mounted.
  - 3. Sections front and rear aligned.
- D. Nominal System Voltage and Main Bus Ratings as indicated on drawings.
- E. Short Circuit Current Rating: Switchboards shall be rated with a minimum short circuit current rating of 100,000 AIC, unless otherwise indicated on drawings.

- F. Service Entrance: Where panelboards are used as service equipment with one or more main service disconnecting and overcurrent protective devices, provide marking by an NRTL acceptable to authority having jurisdiction indicating panelboard is suitable for use as service equipment. Coordinate with utility company for any additional requirements.
- G. Indoor Enclosure: Steel, NEMA 250, Type 1 unless otherwise.
  - 1. Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
  - 2. Provide removable steel base channels bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting. The framework is to be formed of code gauge steel, rigidly welded together to support all cover plate, bussing and component devices.
  - 3. All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.
- H. Customer Metering Compartment: Provide a separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- I. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- J. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- K. Provide Pull Box on Top of Switchboard when required by quantities and sizes of feeders:
  - 1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
  - 2. Set back from front to clear any circuit-breaker removal mechanisms.
  - 3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
  - 4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- L. Buses and Connections: Three phase, four wire unless otherwise indicated.
  - 1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
  - 2. Phase-, Neutral, and Ground -Bus Material: Tin-plated, Hard-drawn copper of 98 percent conductivity.
  - 3. Copper feeder circuit-breaker line connections.
  - 4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
  - 5. Ground Bus: Size per current NEC and UL 891 Tables 28.1 and 28.2, equipped with pressure connectors for feeder and branch circuit ground conductors.
  - 6. Main-Phase Buses, Neutral Buses, and Equipment-Ground Buses: Uniform full capacity for entire length of switchboard's main and distribution sections to comply with ampacity

indicated. Tapered bus is not permitted. Provide sufficient cross-sectional area to meet UL 891 temperature rise requirements. Provide for future extensions from both ends.

7. Disconnect Links:
  - a. Isolate neutral bus from incoming neutral conductors.
  - b. Bond neutral bus to equipment-ground bus with an appropriately sized main bonding conductor for switchboards utilized as service equipment or separately derived systems.

- M. Future Devices: Equip all unused spaces and compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment to allow future installation of OCPDs.

## 2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
  1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings where indicated:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long and short time adjustments.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
  4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
  5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
  6. MCCB Features and Accessories:
    - a. Standard frame sizes, trip ratings, and number of poles.
    - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits; Type HACR for heating, air-conditioning, and refrigeration equipment.
    - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    - e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    - f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    - g. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

- h. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- B. Provide equipment ground fault protection for all overcurrent protective devices 1000 amps or greater on 480Y/277V systems.
- C. Provide arc energy reduction maintenance switch for all overcurrent protective devices rated 1200 amps or greater or where the continuous current trip setting can be adjusted to 1200A or greater.
- D. Isolate Circuit breakers for fire pumps per NFPA and UL requirements.

## 2.4 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, ANSI/IEEE C57.13, and the following:
  - 1. Potential Transformers: Secondary voltage rating of 120 volts and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
  - 2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
  - 3. Control Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
  - 4. Current Transformers for Neutral and Ground Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit breaker ground fault protection.

## 2.5 METERING

- A. Comply with requirements in Section 260913, "Electrical Power Monitoring" for integral power meters.

## 2.6 SURGE PROTECTIVE DEVICES

- A. Where Switchboards are indicated with integral SPD, comply with requirements in Section 264300, "Surge Protective Devices". Surge protective devices shall be installed by, and shipped from, the electrical distribution equipment manufacturer's factory.

## 2.7 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer, if required.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for #8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

## 2.8 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Lock-out, Tag-out: All circuit breakers in the Switchboard to include fixed padlock attachments.

## 2.9 IDENTIFICATION AND MARKINGS

- A. Mimic bus: Provide anodized aluminum or laminated plastic mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
  - 1. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- B. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components complete with lettering designations.
- C. Service Equipment Label: Where Switchboard is provided with one or more service disconnecting and overcurrent protective devices, provide NRTL label indicating use as service equipment.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.
- B. Examine Switchboard interior and exterior before installation. Reject Switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive Switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.
  - 1. Verify concrete pads are level and free of irregularities.
  - 2. Ensure area to receive switchboard has adequate clearance for switchboard installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install Switchboards and accessories according to manufacturer's written guidelines, NECA 400 and NEMA PB 2.1.



- B. Equipment Mounting: Install Switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 and Section 260500, "Common Work Results for Electrical Systems."
  - 1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
  - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Install anchor bolts to elevations required for proper attachment to Switchboards.
- C. Temporary Lifting Provisions: Remove any temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from Switchboard units and components.
- D. Operating Instructions: Frame and mount basic operating instructions for Switchboards, including any control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of Switchboards.
- E. Install filler plates in unused spaces of panel-mounted sections.
- F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
- G. Comply with NECA 1.

### 3.3 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.
- B. Provide ground bushings and bonding conductor connections to the equipment ground bus sized per NFPA 70 on each metallic conduit entering or leaving the switchboard and at the terminal end for each continuous metallic feeder conduit.
- C. Support and secure conductors within the switchboard according to NFPA 70.

### 3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553, "Identification for Electrical Systems"
  - 1. Identify field-installed conductors, interconnecting wiring, and components

2. Provide warning signs and labels to advise personnel of possible hazards in accordance with UL, NFPA 70, NFPA 70E, and other applicable standards.
3. Provide nameplate for each switchboard compartment.
4. Provide nameplate for each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors.
5. All distribution equipment shall be shipped from the manufacturer with factory-applied warning labels affixed to the outside front of the equipment (as it will be installed per the plans). All labeling shall be in compliance with NFPA 70 requirements.
6. Labels affixed to equipment by the equipment manufacturer shall comply with drawing and specification labeling requirements or shall be omitted by the manufacturer and field-installed by the Contractor. Labels which are factory-installed and not in compliance shall be removed and replaced and equipment enclosures refinished or replaced by the manufacturer to repair finish.

### 3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Tests and Inspections:
  1. Visual and Mechanical Inspection: Provide manufacturer's standard start-up inspections, including the following:
    - a. Examine equipment nameplate data and confirm proper identification.
    - b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
    - c. Inspect anchorage, alignment, and grounding.
    - d. Verify controls and instrumentation, ensuring that current and potential transformer ratios are correct.
    - e. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
    - f. Exercise all active components.
    - g. Inspect all mechanical indicating devices for correct operation.
    - h. Physically test key interlock systems to check for proper functionality prior to energizing.
  2. Electrical Acceptance Testing: Provide manufacturer's standard start-up testing, including the following:
    - a. Perform insulation resistance test for one minute on each switchboard bus section. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test. Test voltages and minimum resistance shall be in accordance with manufacturer's published data.
    - b. Perform a control wiring performance test by applying control voltage.
  3. Circuit Breaker Testing: For all circuit breakers with electronic trip units, determine minimum pickup current, long-time and short-time pickup and delay, and instantaneous pickup by secondary current injection. Certify compliance with test parameters and ensure settings match recommendations from final approved power system study.

4. Test ground-fault protection of equipment for service equipment per NFPA 70.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

- C. Switchboard will be considered defective if it does not pass tests and inspections.
- D. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest as specified above.
- E. Prepare test and inspection reports, including a certified report that identifies Switchboards included. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges and time delay settings to recommended values identified in the final approved power system study.

### 3.7 DEMONSTRATION

- A. Engage a factory-authorized instructor to train Owner's maintenance personnel to adjust, operate, and maintain Switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram any microprocessor-based trip, monitoring, and communication units.
- B. Training shall consist of not less than one session with four hours of onsite classroom and hands-on instruction for a minimum of four attendees. Training shall cover the following topics at a minimum:
  1. Theory of operation
  2. Operation of Switchboard and components
  3. Maintenance and configuration
  4. Troubleshooting and Repair
  5. Replacement of components.

END OF SECTION 262413

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## SECTION 262416 - PANELBOARDS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: Section includes requirements for the provision of Panelboards including manufacturing, fabrication, configuration and installation as required for the complete performance of the Work, as shown on the Drawings, as specified herein.
- B. Section Includes:
  - 1. Distribution panelboards
  - 2. Lighting and appliance branch-circuit panelboards
  - 3. Disconnecting and overcurrent protective devices.
- C. Related Requirements:
  - 1. Refer to Section 260500, "Common Work Results for Electrical Systems" for requirements related to equipment supports.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. AFCI: Arc-fault circuit interrupter.
  - 2. GFCI: Ground-fault circuit interrupter.
  - 3. GFPE: Ground-fault protection of equipment.
  - 4. MCCB: Molded Case Circuit Breaker
  - 5. SWD: Switching Duty
  - 6. VPR: Voltage protection rating.
- B. Definitions
  - 1. Panelboard: A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front.

- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
1. National Electrical Contractors Association (NECA):
    - a. NECA 407, "Standard for Installing and Maintaining Panelboards"
  2. National Electrical Manufacturers Association (NEMA):
    - a. NEMA AB 1, "Molded Case Circuit Breakers and Molded Case Switches."
    - b. NEMA PB 1, "Panelboards."
    - c. NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less."
  3. Underwriter Laboratories (UL):
    - a. UL 50, "Enclosures for Electrical Equipment, Non-Environmental Considerations."
    - b. UL 67, "Standard for Panelboards."
    - c. UL 489, "Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures."

#### 1.4 SEQUENCING

- A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

#### 1.5 SUBMITTALS

- A. Product Data: For each type of panelboard,
1. Include materials, switching and overcurrent protective device, accessories, and component indicated.
  2. Include manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
  2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  3. Detail bus configuration, current, and voltage ratings.
  4. Short-circuit current rating of panelboards and overcurrent protective devices.
  5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  6. Include wiring diagrams for power, signal, and control wiring.

C. Closeout Submittals

1. Operation and Maintenance Data: For Panelboards and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
  - a. Routine maintenance requirements for panelboards and all installed components.
  - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices
  - c. Time-current coordination curves for each type and rating of overcurrent protective device included in Panelboards.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of qualified workers as defined in NEMA PB 1.1 and trained in electrical safety as required by NFPA 70E.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1. Handle carefully to avoid damage to internal components, enclosure, and finish.
- B. Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental concerns.

1.8 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Distribution equipment sizes and equipment layouts shown on drawings shall be considered the basis of design. Equipment sizes vary by manufacturer. If the proposed equipment is physically larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.
- C. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access, and working space requirements of the NEC and Owner.

## 1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards, circuit breakers, finishes, controls, components, and accessories that fail in materials or workmanship within 12 months from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Square D.
  - 2. Eaton.
  - 3. Siemens.
  - 4. ABB.
- B. Source Limitations: Obtain panelboards, overcurrent protection devices, and all other electrical distribution equipment through one source from a single manufacturer.

### 2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70 and NEMA PB 1.
- C. Provide circuit breaker type panelboards unless noted otherwise.
- D. Enclosures: Flush- or surface-mounted, dead-front cabinets as indicated on drawings.
  - 1. Rated for environmental conditions at installed location.
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    - b. Outdoor and Wet Locations: NEMA 250, Type 3R.
    - c. Corrosive and Wash Down Environments: NEMA 250, Type 4X.
    - d. Kitchens: NEMA 250, Type 1 with Stainless Steel cover.
  - 2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover
  - 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box and keep tight to wall with no gaps allowing access to live parts. Oversize trims will not be acceptable
  - 4. Interior trim shall be of dead-front construction to shield user from all energized parts.
  - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
  - 6. Materials and Finishes:



- 
- a. Panel Fronts and Trim: Galvanized Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    - b. Back Boxes: Galvanized steel with the same finish as panels and trim. Unpainted galvanized steel is not acceptable.
  - 7. Boxes shall have removable end walls. End walls shall not be provided with concentric knockouts. Boxes shall have welded interior mounting studs. Interior mounting brackets are not required.
  - 8. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
  - 9. All lock assemblies shall be keyed alike.
- E. Incoming Mains:
- 1. Circuit breaker or Lugs only as indicated on drawings
  - 2. Location: Top or bottom to match feeder conduit entry.
  - 3. Feeders routed through the side gutters to reach the top or bottom main breakers from the opposite end of the panel are not acceptable.
  - 4. Main lugs or main breakers shall have barriers on five sides.
- F. Phase, Neutral, and Ground Busses:
- 1. Material: Hard-drawn copper, 98 percent conductivity.
    - a. Bus shall be fully rated the entire length, with one continuous bus bar per phase.
  - 2. Phase bussing shall be pre-drilled to accommodate field installable options.
  - 3. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
  - 4. Equipment Ground Bus: Extend full length of panelboard and adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
  - 5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
- G. Conductor Connectors: Suitable for use with conductor material and sizes.
- 1. Material: Tin-plated aluminum.
  - 2. Terminations shall allow use of 75 deg C rated conductors without derating.
  - 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
  - 4. Main and Neutral Lugs: Mechanical type.
  - 5. Ground Lugs and Bus-Configured Terminators: Mechanical type.
  - 6. Feed-Through Lugs: Where indicated provide mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device. Provide where indicated on drawings.
  - 7. Subfeed (Double) Lugs: Where indicated provide mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
  - 8. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus where indicated.

- H. Service Entrance: Where panelboards are used as service equipment with one or more main service disconnecting and overcurrent protective devices, provide marking by an NRTL acceptable to authority having jurisdiction indicating panelboard is suitable for use as service equipment. Coordinate with utility company for any additional requirements.
- I. Future Devices: Provide mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices. Where panelboards are noted to have "space" or "space only", this shall be prepared space with all bussing, lugs, etc. as required to accept future installation of over-current devices.
- J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Panelboard and overcurrent protective device short circuit ratings shall be at least 110 percent of the actual available fault current.
  - 1. Panelboards rated 240V or less: minimum 10,000 A.
  - 2. Panelboards rated above 240V: minimum 14,000 A.

## 2.3 DISTRIBUTION PANELBOARDS

- A. Panelboards: NEMA PB 1, power and feeder distribution type.
- B. Provide bolt-on circuit breakers for overcurrent protective devices.
- C. Doors: Secured with three point vault-type latch with tumbler lock; keyed alike. For doors more than 48 inches high, provide two latches.
- D. All panelboards shall be capable of accepting 225 amp 3 pole branch breakers as a minimum unless otherwise noted.

## 2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- B. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- C. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.
- D. All panelboards shall have space to accept forty-two 20 amp single pole circuit breakers unless otherwise noted.

## 2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:
    - a. Inverse time-current element for low-level overloads.
    - b. Instantaneous magnetic trip element for short circuits.
    - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  2. Adjustable Instantaneous-Trip Circuit Breakers:
    - a. Magnetic trip element with front-mounted, field-adjustable trip setting.
  3. Electronic trip circuit breakers:
    - a. RMS sensing.
    - b. Field-replaceable rating plug or field-replaceable electronic trip.
    - c. Digital display of settings, trip targets, and indicated metering displays.
    - d. Multi-button keypad to access programmable functions and monitored data.
    - e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
    - f. Integral test jack for connection to portable test set or laptop computer.
    - g. Field-adjustable Instantaneous, Long- and short-time pickup, and Ground-fault pickup settings.
  4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
  5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
  6. AFCI Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
  7. MCCB features and accessories:
    - a. Standard frame sizes, trip ratings, and number of poles.
    - b. Breaker handle indicates tripped status.
    - c. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    - e. Shunt Trip: 120 V or 24V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
    - f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
    - g. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
    - h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
- B. Provide Ground Fault protection for circuit breakers rated 1000 A and higher on solidly grounded wye systems more than 150V to ground.
- C. Provide Arc Flash energy reducing maintenance switch with local status indicator for circuit breakers rated 1200A and higher or where circuit breaker trip setting can be adjusted to 1200A or greater.

## 2.6 METERING

- A. Where indicated comply with requirements in Section 260913, "Electrical Power Monitoring."

## 2.7 SURGE PROTECTION DEVICES

- A. Where panelboards are indicated with integral SPD, comply with requirements in Section 264300, "Surge Protective Devices". Factory install SPDs prior to shipment.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work. Ensure area to receive panelboard has adequate clearance for panelboard installation.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.
- C. Temporary Lifting Provisions: Remove any temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- D. Mount top of trim 90 inches above finished floor unless otherwise indicated or where required to maintain center of trip handle on overcurrent protection devices below 79-inches. Where mounted in groups, align top of trim or tub for all panels in an area.
- E. Mount panelboard cabinet plumb and rigid without distortion of box.
- F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Provide steel slotted support structures where required for freestanding equipment or where building mounting surface is unsuitable.

- H. Install overcurrent protective devices and controllers not already factory installed. Set field-adjustable, circuit-breaker trip ranges.
- I. Install filler plates in unused spaces.
- J. Stub four (4) 1-inch and two (2) 1-1/4-inch empty conduits from recessed panelboard into accessible ceiling space or space designated to be ceiling space in the future. Provide suitable closures for spare conduits and identify with a suitable label.
- K. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- L. Comply with NECA 1.

### 3.3 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

### 3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553, "Identification for Electrical Systems" and as noted below:
  - 1. Provide a directory card inside each door, covered with a plastic non-yellowing shield. Directory Card to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer to create directory in Microsoft Excel; handwritten directories are not acceptable. Digital versions to be provided to Owner.
  - 2. The room numbers used to fill out the panel directories shall match the actual final name and numbering scheme selected by the Owner. They shall not be filled out per the construction drawing numbering scheme, unless the Contractor is directed to do so by the Architect or Engineer.
  - 3. Provide nameplate for each panelboard.
  - 4. For distribution panelboards, provide nameplate for each branch circuit device.
  - 5. All distribution equipment shall be shipped from the manufacturer with factory-applied warning labels affixed to the outside front of the equipment (as it will be installed per the plans). All labeling shall be in compliance with NFPA 70 requirements.
  - 6. Labels affixed to equipment by the equipment manufacturer shall comply with drawing and specification labeling requirements or shall be omitted by the manufacturer and field-installed by the Contractor. Labels which are factory-installed and not in compliance shall be removed and replaced and equipment enclosures refinished or replaced by the manufacturer to repair finish.

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following Tests and Inspections:
  - 1. Visual and Mechanical Inspection:
    - a. Examine equipment nameplate data and confirm proper identification.
    - b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
    - c. Inspect anchorage, alignment, and grounding.
    - d. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
    - e. Exercise all active components.
    - f. Inspect all mechanical indicating devices for correct operation.
    - g. Physically test key interlock systems to check for proper functionality prior to energizing.
  - 2. Circuit Breaker Testing: For all circuit breakers with electronic trip units, determine minimum pickup current, long-time and short-time pickup and delay, and instantaneous pickup by secondary current injection. Certify compliance with test parameters and ensure settings match recommendations from final approved power system study.
  - 3. Test ground-fault protection of equipment for service equipment per NFPA 70.
  - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Panelboards will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

### 3.7 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573, "Power System Studies".

- C. All circuit breakers identified as spares shall be left in the OFF position.

END OF SECTION 262416

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## SECTION 262726 - WIRING DEVICES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. This section of the specifications covers all wiring devices and cover plates, standard, weatherproof and dust-tight.
- B. Section Includes:
  - 1. Straight Blade receptacles.
  - 2. GFCI receptacles.
  - 3. AFCI receptacles.
  - 4. USB receptacles.
  - 5. SPD receptacles.
  - 6. Twist-locking receptacles.
  - 7. Controlled receptacles.
  - 8. General use snap switches.
  - 9. Manual Motor Control switches.
  - 10. Wall Plates.
  - 11. Cord and plug sets.
  - 12. Floor service fittings.
  - 13. Poke-through assemblies.
  - 14. Prefabricated multioutlet assemblies.
  - 15. Service poles.
  - 16. Cord Reels.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. AFCI: Arc-fault circuit interrupter.
  - 2. CR: Corrosion Resistant
  - 3. EMI: Electromagnetic interference.
  - 4. GFCI: Ground-fault circuit interrupter.
  - 5. IG: Isolated Ground
  - 6. SPD: Surge Protective Device
  - 7. TR: Tamper Resistant.
  - 8. USB: Universal Serial Bus.
  - 9. WR: Weather Resistant.

B. Definitions

1. Emergency Electrical Systems: Those systems legally required and classed as emergency by NFPA 70 Article 700, municipal, state, other codes, or by any government agency having jurisdiction.
2. Essential Electrical Systems: Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system as defined by NFPA 70 Article 517 and NFPA 99.
3. Outlet: A point on the wiring system at which current is taken to supply utilization equipment.
4. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
5. Receptacle. A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Contractors Association (NECA):
  - a. NECA 130, "Standard for Installing and Maintaining Wiring Devices"
2. National Electrical Manufacturers Association (NEMA)
  - a. NEMA WD 1, "General Color Requirements for Wiring Devices"
  - b. NEMA WD 6, "Wiring Devices—Dimensional Specifications"

1.4 SUBMITTALS

- A. Product Data: For each type of product.
- B. Schedules: List of legends and description of materials and process used for pre-marking wall plates.
- C. Samples: Where requested by architect or engineer, one for each type of device and wall plate, in each color specified.
- D. Closeout Submittals
  1. Operation and Maintenance Data: For Wiring Devices to include in operation and maintenance manuals.
  2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide product indicated or equal from one of the following:
  - 1. Eaton/Arrow Hart
  - 2. Hubbell
  - 3. Leviton
  - 4. Pass & Seymour/Legrand
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

### 2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Devices for Fixtures, Furnishings, and Equipment:
  - 1. Receptacles: Match plug configurations.
  - 2. Cord and Plug Sets: Match equipment requirements.
- E. All terminations shall be side-wired clamping type. "Backstab" terminations or modular connectors are not permitted.
- F. Device Color:
  - 1. Wiring devices in finished spaces connected to normal power system: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
  - 2. Wiring Devices in unfinished spaces connected to normal power system: Grey unless otherwise indicated or required by NFPA 70 or device listing.
  - 3. Wiring Devices Connected to Emergency or Essential Electrical System: Red.
  - 4. SPD Devices: Blue.
  - 5. Isolated-Ground Receptacles: Orange or as specified above with orange triangle on face.
- G. Wall Plate Color:
  - 1. For plastic covers, match device color unless noted otherwise.
  - 2. Where normal and essential system devices are ganged under a common wall plate, the plate shall be the color of normal power plates.

## 2.3 SPECIFICATION GRADE STRAIGHT-BLADE RECEPTACLES

- A. Specification Grade Receptacle, Comply with NEMA WD 6, UL 498, FS W-C-596.

| TYPE      | RATING    | CONFIGURATION | BASIS OF DESIGN   |
|-----------|-----------|---------------|-------------------|
| Duplex    | 20A, 125V | NEMA 5-20R    | Hubbell 5362      |
| Single    | 20A, 125V | NEMA 5-20R    | Hubbell 5361      |
| Duplex-TR | 20A, 125V | NEMA 5-20R    | Hubbell 5362TR    |
| Duplex-IG | 20A, 125V | NEMA 5-20R    | Hubbell IG5362    |
| Duplex-WR | 20A, 125V | NEMA 5-20R    | Hubbell 5362WR    |
| Duplex-CR | 20A, 125V | NEMA 5-20R    | Hubbell HBL53CM62 |
| Single    | 30A, 250V | NEMA 6-30R    | Hubbell HBL9330   |
| Single    | 50A, 250V | NEMA 6-50R    | Hubbell HBL9367   |
| Single    | 20A, 250V | NEMA 10-20R   | Hubbell HBL9326   |

## 2.4 SPECIFICATION GRADE GFCI RECEPTACLES

- A. Specification Grade GFCI Receptacles, Comply with UL 498, FS W-C-596, and UL 943 Class A.
- B. Non-feed through type unless otherwise required, Integral self-testing GFCI with "Test" and "Reset" buttons and LED indicator light that is lighted when the unit is tripped. If critical components are damaged and ground fault protection is lost, power to receptacle shall be discontinued.

| TYPE                   | RATING    | CONFIGURATION | BASIS OF DESIGN   |
|------------------------|-----------|---------------|-------------------|
| Duplex GFCI            | 20A, 125V | NEMA 5-20R    | Hubbell GFRST20   |
| Duplex GFCI with Alarm | 20A, 125V | NEMA 5-20R    | Hubbell GFRST20A  |
| Duplex GFCI - TR       | 20A, 125V | NEMA 5-20R    | Hubbell GFTRST20  |
| Duplex GFCI - WR       | 20A, 125V | NEMA 5-20R    | Hubbell GFTWRST20 |
| Duplex GFCI - CR       | 20A, 125V | NEMA 5-20R    | Hubbell GFRST52M  |
| GFCI Blank Face        | 20A, 125V |               | Hubbell GFBFST20  |

## 2.5 SPECIFICATION GRADE AFCI RECEPTACLES

- A. Specification Grade AFCI Receptacles, Comply with UL 498, FS W-C-596, and UL 1699A.
- B. Non-feed through type unless otherwise required, Integral self-testing AFCI with "Test" and "Reset" buttons and LED indicator light that is lighted when the unit is tripped. If critical components are damaged and ground fault protection is lost, power to receptacle shall be discontinued.

| TYPE                 | RATING    | CONFIGURATION | BASIS OF DESIGN  |
|----------------------|-----------|---------------|------------------|
| Duplex AFCI - TR     | 20A, 125V | NEMA 5-20R    | Hubbell AFR20TR  |
| Duplex AFCI/GFCI -TR | 20A, 125V | NEMA 5-20R    | Hubbell AFGF20TR |
| AFCI Blank Face      | 20A, 125V |               | Hubbell AFR20BF  |

## 2.6 USB RECEPTACLES

- A. USB Charging Receptacle and Outlet, Comply with UL 1310 and USB 3.0 devices.
- B. Dual port, combination USB Type A and C, 5 V dc, and 5 A per receptacle (minimum).

| TYPE            | RATING    | CONFIGURATION | BASIS OF DESIGN    |
|-----------------|-----------|---------------|--------------------|
| Duplex USB - TR | 20A, 125V | NEMA 5-20R    | Hubbell USB20AC5   |
| Duplex USB - WR | 20A, 125V | NEMA 5-20R    | Hubbell USB20AC5WR |

## 2.7 SPECIFICATION GRADE SPD RECEPTACLES

- A. Specification Grade SPD Receptacles, Comply with UL 498, FS W-C-596, and UL 1449, Type 3:
- B. Self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. Visual and audible SPD indication, with LED indicator light visible in face of device to indicate device is "active" or "no longer in service."
- C. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 500 V and minimum single transient pulse energy dissipation of 340 J in each mode, according to IEEE C62.41.2 and IEEE C62.45.

| TYPE       | RATING    | CONFIGURATION | BASIS OF DESIGN   |
|------------|-----------|---------------|-------------------|
| Duplex SPD | 20A, 125V | NEMA 5-20R    | Hubbell HBL5362SA |

## 2.8 HOSPITAL-GRADE RECEPTACLES

- A. Hospital-Grade Receptacles, Comply with requirements above and UL 498 Supplement SD:
- B. Marking: Listed and labeled as complying with NFPA 70, Article 517 "Health Care Facilities".

| TYPE             | RATING    | CONFIGURATION | BASIS OF DESIGN    |
|------------------|-----------|---------------|--------------------|
| Duplex           | 20A, 125V | NEMA 5-20R    | Hubbell HBL8300H   |
| Single           | 20A, 125V | NEMA 5-20R    | Hubbell HBL8310    |
| Duplex - TR      | 20A, 125V | NEMA 5-20R    | Hubbell 8300TRA    |
| Duplex - IG      | 20A, 125V | NEMA 5-20R    | Hubbell IG8300     |
| Duplex GFCI      | 20A, 125V | NEMA 5-20R    | Hubbell GFRST83    |
| Duplex GFCI - TR | 20A, 125V | NEMA 5-20R    | Hubbell GFTRST83   |
| Duplex USB       | 20A, 125V | NEMA 5-20R    | Hubbell USB8300AC5 |
| Duplex SPD       | 20A, 125V | NEMA 5-20R    | Hubbell 8362       |

## 2.9 TWIST-LOCKING RECEPTACLES

- A. Twist-Lock, Single Receptacles, with matching plug as required by equipment. Comply with NEMA WD 6, UL 498, FS W-C-596.

| TYPE   | RATING    | CONFIGURATION | BASIS OF DESIGN |
|--------|-----------|---------------|-----------------|
| Single | 20A, 125V | NEMA L5-20R   | Hubbell HBL2310 |
| Single | 20A, 250V | NEMA L6-20R   | Hubbell HBL2320 |
| Single | 20A, 277V | NEMA L7-20R   | Hubbell HBL2330 |

## 2.10 CONTROLLED RECEPTACLES

- A. Specification Grade Receptacle, Permanently marked and suitable for use with automatic switching means. Comply with NEMA WD 6, UL 498B, FS W-C-596.

| TYPE                       | RATING    | CONFIGURATION | BASIS OF DESIGN  |
|----------------------------|-----------|---------------|------------------|
| Duplex Single Face Control | 20A, 125V | NEMA 5-20R    | Hubbell 5362C1TR |

|                         |           |            |                  |
|-------------------------|-----------|------------|------------------|
| Duplex Two Face Control | 20A, 125V | NEMA 5-20R | Hubbell 5361C2TR |
|-------------------------|-----------|------------|------------------|

## 2.11 GENERAL USE SNAP SWITCHES

### A. Switches, 120/277 V, Comply with UL 20 and FS W-S-896.

| TYPE        | RATING        | CONFIGURATION | BASIS OF DESIGN |
|-------------|---------------|---------------|-----------------|
| Single Pole | 20A, 120/277V |               | Hubbell 1221    |
| Double Pole | 20A, 120/277V |               | Hubbell 1222    |
| Three Way   | 20A, 120/277V |               | Hubbell 1223    |
| Four Way    | 20A, 120/277V |               | Hubbell 1224    |

### B. Pilot-Light Switches, illuminated when switch is ON:

| TYPE        | RATING        | CONFIGURATION | BASIS OF DESIGN |
|-------------|---------------|---------------|-----------------|
| Single Pole | 20A, 120/277V |               | Hubbell 1221PL  |

### C. Illuminated Switches, illuminated when switch is OFF:

| TYPE        | RATING        | CONFIGURATION | BASIS OF DESIGN |
|-------------|---------------|---------------|-----------------|
| Single Pole | 20A, 120/277V |               | Hubbell 1221IL  |

### D. Key-Operated Switches, Factory-supplied key in lieu of switch handle:

| TYPE        | RATING        | CONFIGURATION | BASIS OF DESIGN |
|-------------|---------------|---------------|-----------------|
| Single Pole | 20A, 120/277V |               | Hubbell 1221L   |
| Three Way   | 20A, 120/277V |               | Hubbell 1223L   |
| Four Way    | 20A, 120/277V |               | Hubbell 1224L   |

### E. Double-Throw, Momentary-Contact, Center-off Switches.

| TYPE        | RATING        | CONFIGURATION | BASIS OF DESIGN |
|-------------|---------------|---------------|-----------------|
| Single Pole | 20A, 120/277V |               | Hubbell 1557    |

|             |           |  |                |
|-------------|-----------|--|----------------|
| Low Voltage | 5A, 24VDC |  | Hubbell 1557LV |
|-------------|-----------|--|----------------|

## 2.12 MANUAL MOTOR CONTROL SWITCHES

- A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle type for manual control of single or three phase motors up to 3/4 HP where overload protection is not required or is provided separately, marked to indicate whether unit is on or off.
  - 1. Standard: Comply with NEMA ICS 2, general purpose, Class A.
- B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle type with integral overload protection for use with single phase motors up to 1HP; marked to show whether unit is off, on, or tripped.
  - 1. Configuration: Non-reversing unless noted otherwise on drawings.
  - 2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor and ambient temperature; external reset push button; melting alloy type.
  - 3. Red pilot light where indicated on drawings.
  - 4. HOA selector switch with dry contact inputs where indicated on drawings.
- C. Provide with NEMA 1, NEMA 3R or other enclosure suitable for the location and atmosphere.
- D. All manual starters located in finished areas shall be in flush-mounted enclosures.

## 2.13 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.
- B. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
- C. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

## 2.14 CORD AND PLUG SETS

- A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
- B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
- C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.



## 2.15 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices.
  - 1. Plate-Securing Screws: Metal with head color to match plate finish.
  - 2. Material for Finished Spaces: Smooth, 0.060-inch high-impact thermoplastic or satin-finished, type 304 stainless steel.
  - 3. Material for Unfinished Spaces: Aluminum or type 430 stainless steel.
  - 4. Material for rough service or corrosive locations including gymnasiums, kitchens, mechanical rooms, material management, and food service areas: satin-finished, Type 304 stainless steel.
    - a. For kitchen and food service areas, provide foam gasket behind plate to help prevent water infiltration.
- B. Material for Interior Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- C. Wet-location, Weatherproof, in-use cover plates: extra duty, suitable for use with and decorator style devices, die-cast aluminum lockable cover, self-closing, gasketed, standard box mounting.
  - 1. Vertical mounting - Hubbell WP26E or equal.
  - 2. Horizontal mounting - Hubbell WP26EH or equal.
- D. Cover plates for lighting control devices exposed to severe physical damage: Low profile, flip-up clear polycarbonate cover. STI Stopper or equal.

## 2.16 FLOOR BOXES AND POKE-THROUGH ASSEMBLIES

- A. Description: Single or multi-service, recess activated, multi-gang floor outlet with devices capable of supplying combinations of power, data, voice, and AV services in a single assembly.
- B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:
  - 1. FSR
  - 2. Hubbell
  - 3. Legrand (Wiremold)
- C. Floor Boxes and Poke-Thru Assemblies
  - 1. Comply with UL514A.
  - 2. Material: Cast metal or sheet metal with finished interior
  - 3. Type: Fully adjustable before and after floor installation.
  - 4. Shape: Rectangular or Round
  - 5. Designed for use with industry standard wall plates, devices, and modular inserts.
  - 6. Painted with corrosion resistant fusion-bonded epoxy, where used in on-grade floor applications.
  - 7. Classified for fire resistance up to 2 hours, where used in rated floors.
  - 8. Evaluated by UL to meet U.S. safety standards for scrub water exclusion.
  - 9. Provide separate paths for management of telecommunications and power cables in compliance with NFPA 76.

10. Cover: ADA-compliant, with less than 0.15-inch rise to cover flange, hinged for 180-degree opening, Gasketed, Die-cast powder coated aluminum suitable for multiple floor surfaces.
  - a. Surface style for carpet and VCT floor finishes.
  - b. Flush style for wood, tile, finished concrete, and terrazzo floor finishes.

## 2.17 PREFABRICATED MULTIOUTLET ASSEMBLIES

- A. Description: Two-piece surface metal raceway, with factory-wired multioutlet harness.
- B. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- C. Raceway Material: Metal, with manufacturer's standard finish.
- D. Multioutlet Harness:
  1. Receptacles: 20-A, 125-V.
  2. Receptacle Spacing: 18 inches unless noted otherwise.
  3. Wiring: No. 12 AWG solid, Type THHN copper.

## 2.18 SERVICE POLES

- A. Dual-Channel Service Poles
  1. Description: Factory-assembled and -wired units to route power and communications cabling from connections above ceiling to outlets below ceiling.
  2. Listed and labeled in accordance with UL 5 for exposed power raceway and fittings, and UL 2024 for communications raceway and fittings.
  3. Poles: Minimum 2.5-inch- square cross-section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
  4. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
  5. Material: Aluminum.
  6. Finishes: Manufacturer's standard painted finish and trim combination.
  7. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, balanced twisted pair data communication cables.

## 2.19 CORD REELS

- A. Description: Reel equipped with, or intended for use with, length of flexible cord, providing means for cord to be unwound by user as desired, providing spring take-up mechanism to rewind cord on reel, and providing latch to restrain action of spring take-up mechanism while cord reel is in use.
- B. Comply with UL 355.

- C. Spring Driven, suitable for industrial and commercial use, No. 12 AWG conductors, 20A rating, Black aluminum housing, Ball stop, pivot base, 40ft spool capacity with double 20A duplex receptacles unless noted otherwise.

### PART 3 - EXECUTION

#### 3.1 APPLICATION

- A. Provide receptacles and cover plates listed for the installed environment.
- B. Outdoor receptacles and receptacles located in wet locations shall be weather resistant, GFCI type, with weather proof enclosure.
- C. Provide GFCI receptacles where required by the NEC in addition to the locations noted on the drawings.
- D. Provide weather-resistant rating for GFCI receptacles installed in wet locations.
- E. Where GFCI receptacles are located in areas that are not readily accessible, provide GFCI blank face device in readily accessible location approved by Architect.
- F. Provide GFCI receptacles with audible alarm for refrigeration and vending applications.
- G. Provide tamper resistant receptacles where required by the NEC in addition to the locations noted on the drawings.

#### 3.2 INSTALLATION

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA 130.
- B. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
- C. Devices that have been installed before painting shall be masked. No plates or covers shall be installed until all finishing and cleaning has been completed. Replace stained or improperly painted wiring devices and coverplates.
- D. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required. Where GFCI receptacles share a single circuit with other devices, a ground fault on any GFCI receptacle shall not interrupt power to downstream devices.
- E. Coordination for all receptacles: Confirm receptacle configuration of all special purpose receptacles with approved submittals prior to installation and provide devices to match equipment plugs. Contractor shall replace any incompatible receptacle discovered during owner move-in.

F. Coordination with Other Trades:

1. Adjust locations of outlets to suit arrangement of partitions and furnishings. Locate outlets to avoid blocking by supports, furnishings, and other architectural fixtures.
2. Adjust locations of floor boxes and poke-throughs to coordinate with locations of structural members, concealed piping, and concealed conduit.
3. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
4. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
5. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
6. Install wiring devices after all wall preparation, including painting, is complete.

G. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Where re-using existing conductors:
  - a. Cut back and pigtail, or replace all damaged conductors.
  - b. Straighten conductors that remain and remove corrosion and foreign matter.
  - c. Pigtail existing conductors is permitted, provided the outlet box is large enough.

H. Device Installation:

1. Replace all devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until all finish work is complete.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. Use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than #12 AWG are installed on 15- or 20-A circuits, splice #12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
10. Install devices and assemblies level, plumb, and square with building lines. Align devices vertically and horizontally. Securely fasten devices into boxes.

I. Device Orientation:

1. Install switches with "OFF" position down.
2. Install ground pin of vertically mounted receptacles **up**, and on horizontally mounted receptacles to the left so the neutral blade is at the top.

J. Device Plates:

1. Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
2. All outlets not provided with wiring devices shall be closed with a blank plate matching other plates in the area.
3. Align coverplate mounting screw slots in the same direction, either vertical or horizontal. Do not overtighten coverplate mounting screws. Overtightening can cause the coverplate to warp, dimple, bend, and in the case of plastic faceplates, crack or break.

3.3 IDENTIFICATION:

A. Comply with Section 260553 "Identification for Electrical Systems."

1. All device wall plates shall be labeled with panel and circuit designation by means of machine printed adhesive tape.
2. All device boxes shall have circuit number identified within the box.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Using a test plug, perform the following tests and inspections for receptacles:

1. Insert and remove test plug to verify that devices are securely mounted.
2. Verify correct configuration of hot, neutral, and ground pins.
3. Verify correct operation of ground fault protective devices.

C. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

END OF SECTION 262726

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## SECTION 262813 - FUSES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: Provide labor, material, equipment, related services, and supervision required for the installation of cartridge fuses where utilized for overcurrent and/or current limitation applications.
- B. Section Includes:
  - 1. Cartridge fuses rated 600V-AC and less for use in control circuits, enclosed switches, panelboards, switchboards, and motor controllers.
  - 2. Spare fuse cabinet.

#### 1.3 REFERENCES

- A. Definitions
  - 1. Fuse: A protective device that opens a circuit during specified overcurrent conditions by means of a current responsive element.
- B. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. National Electrical Contractors Association (NECA)
    - a. NECA 420, "Fuse Applications"

#### 1.4 SEQUENCING

- A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

## 1.5 SUBMITTALS

- A. Product Data: For each fuse type indicated:
  - 1. Include let-through current curves for fuses with current-limiting characteristics.
  - 2. Time-current curves, coordination charts and tables, and related data.
- B. Ambient Temperature Adjustment Information: Where ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
  - 1. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
  - 2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
- C. Closeout Submittals
  - 1. Operation and Maintenance Data: For Fuses include in emergency, operation, and maintenance manuals.
  - 2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Let-through current curves for fuses with current-limiting characteristics.
    - b. Time-current curves, coordination charts and tables, and related data.
    - c. Ambient temperature adjustment information.

## 1.6 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels indicated in power system study.

## 1.7 MAINTENANCE MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: Equal to one spare for every 10 installed units, but not less than 5 units for each size and type.
  - 2. Fuse Pullers: Two for each size and type.

## 1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace fuses that fail in materials or workmanship within 12 months from date of Substantial Completion.

## 1.9 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.



## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Bussmann, Inc.
  - 2. Littlefuse, Inc.
  - 3. Mersen USA.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

### 2.2 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with:
  - 1. NEMA FU 1 – Low Voltage Cartridge Fuses.
  - 2. UL 248 – Standard for Low Voltage Fuses.
  - 3. UL 512 – Fuseholders.

### 2.3 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
  - 1. Type RK-1: 250 or 600-V, zero- to 600-A rating, 200 kAIC minimum, fast acting or time delay.
  - 2. Type RK-5: 250 or 600-V, zero- to 600-A rating, 200 kAIC minimum, fast acting or time delay.
  - 3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC minimum, fast acting or time delay.
  - 4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC minimum, time delay option.
- B. Voltage: Rating suitable for circuit phase-to-phase voltage.
- C. Provide dual element fuses with separate overload and short circuit elements.

### 2.4 SPARE-FUSE CABINET

- A. Manufacturer: Bussmann #SFC-FUSE-CAB spare fuse cabinet or equal.

- B. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
  - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
  - 2. Finish: Gray, baked enamel.
  - 3. Identification: "SPARE FUSES" in 1-1/2 inch high white letters on black lamicoid plate. Mount plate on exterior of door.
  - 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 FUSE APPLICATIONS

- A. Service, Feeders, and Branch Circuits (601-6000A): Class L, time delay. Bussmann HI-CAP Fuses KRP-C or equal. Fuses shall hold 500% of rated current for a minimum of 4 seconds.
- B. Feeders and Branch Circuits (0-600A): Class RK1, time delay. Bussmann Low-Peak Dual Element Fuses, LPN-RK (250 volts) or LPS-RK (600 volts) or equal. The fuse shall hold 500% of rated current for a minimum of 10 seconds.
- C. Motor Circuits – Class RK1 or Class L, time delay as indicated above.
  - 1. Motor with 1.15 service factor: Size at 125% of motor FLA. For high inrush current applications size 150% to 200% of motor FLA.
  - 2. Motor with 1.0 service factor: Size at 115% of motor FLA.
- D. Control Circuits: Class CC, time delay. Bussmann Low-Peak Fuses LP-CC or equal. Fuses shall hold 200% of rated current for a minimum of 12 seconds.

- E. Adjust fuse type and selection as required to ensure available fault current at equipment controllers indicated in power systems study does not exceed labeled SCCR values.

### 3.3 INSTALLATION

- A. Fuses shall be shipped separately. Any fuses shipped installed in equipment, shall be replaced by the Electrical Contractor with new fuses as specified above prior to energizing at no additional expense to Owner. All fuses shall be stored in moisture free packaging at job site and shall be installed immediately prior to energizing of the circuit in which it is applied.
- B. No fuses shall be installed in the equipment until the installation is complete, including tests and inspections required prior to being energized. All fuses shall be of the same manufacturer to ensure retention of selective coordination, as designed.
- C. Provide a complete set of fuses for all fusible devices. Arrange fuses so rating information is readable without removing fuse.
- D. Install spare-fuse cabinet(s). Locate in Main Electrical Room.
- E. Upon completion of the building, the Contractor shall provide the Owner with spare fuses in Spare-Fuse Cabinet.

### 3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems".
  - 1. Indicate fuse rating and type on the outside door of each fused switch.

END OF SECTION 262813

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## SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: Section includes requirements for the provision of individually enclosed switches and circuit breakers including manufacturing, fabrication, configuration and installation as required for the complete performance of the Work, as shown on the drawings and specifications
- B. Section includes:
  - 1. Fusible and Non-Fusible Switches.
  - 2. Enclosed Circuit Breakers.
  - 3. Elevator Shunt Trip Switches.
  - 4. Enclosures.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. HD: Heavy Duty
  - 2. MCCB: Molded Case Circuit Breaker
  - 3. NC: Normally Closed
  - 4. NO: Normally Open
  - 5. SCCR: Short Circuit Current Rating
- B. Definitions
  - 1. Disconnect: A switch, device, group of devices, or other means used to disconnect conductors of a circuit from their source of supply.
  - 2. Switch (switching device): A device, manually operated, unless otherwise designated, for opening and closing or for changing the connection of a circuit. Also referred to as safety switches or disconnect switches.

#### 1.4 SEQUENCING

- A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for

manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

## 1.5 SUBMITTALS

- A. Product Data: For each product type.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Short-circuit current ratings (interrupting and withstand, as appropriate).
  - 3. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
  - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  - 3. Detail bus configuration, current, and voltage ratings.
  - 4. Short-circuit current rating of overcurrent protective devices.
  - 5. Include evidence of NRTL listing for series rating of installed devices.
  - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 7. Include wiring diagrams for power, signal, and control wiring.
  - 8. Cable terminal size and quantity.
- C. Closeout Submittals
  - 1. Operation and Maintenance Data: For enclosed switches and circuit breakers include in emergency, operation, and maintenance manuals.
  - 2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

## 1.6 COORDINATION

- A. Product Selection for Restricted Space: Drawings indicate space available for enclosed switches including clearances between enclosed switches and adjacent surfaces and other items. Furnish and install equipment to comply with NEC clearances.

## 1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace devices that fail in materials or workmanship within 12 months from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB/General Electric.
  - 2. Eaton Electrical Inc.
  - 3. Siemens.
  - 4. Square D
- B. Source Limitations: Obtain enclosed switches, overcurrent protection devices, and all other electrical distribution equipment through one source from a single manufacturer unless approved otherwise.

### 2.2 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. Service-Rated Switches and Circuit Breakers: Labeled for use as service equipment.
- D. Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Switch and overcurrent protective device short circuit ratings shall be at least 110% of the actual available fault current.

### 2.3 FUSIBLE AND NON-FUSIBLE SWITCHES

- A. Type HD, Heavy Duty, Single Throw, 250-VAC or 600-VAC, 1200 A and Smaller unless noted otherwise.
- B. Quick-make, quick-break operating handle and switch mechanism integral to box.
- C. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses where indicated.
- D. Externally operable dual interlocked handle to prevent opening front cover with switch in ON position, or closing switch when door is open. Visible load interrupter knife switch blades in the off position with door open.
- E. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

- F. All current carrying parts shall be plated by an electrolytic process to resist corrosion and to promote cooling.
- G. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - 3. Lugs: UL Listed, mechanical type, front removeable, and suitable for number, size, and conductor material at 75 deg C.
  - 4. Auxiliary Contact Kit: NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating as required for application.
  - 5. Electrical Interlock Kit: Pivot arm operated from the switch mechanism, breaking a control circuit before the main switch blades break.
- H. For receptacle switches provide interlocking linkage between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

## 2.4 ENCLOSED MOLDED-CASE CIRCUIT BREAKERS

- A. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.
- D. MCCBs shall be equipped with a device for locking in the open position.
- E. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- F. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
  - 1. Long-time, Short-time, and Instantaneous trip unless noted otherwise on drawings.
- G. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.



- H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single-, two-pole, and three-pole configurations with Class A ground-fault protection (6-mA trip).
- I. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- J. Features and Accessories:
  - 1. Standard frame sizes, trip ratings, and number of poles.
  - 2. Lugs: UL Listed, mechanical type, suitable for number, size, trip ratings, and conductor material at 75 deg C.
  - 3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
  - 4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact. Coordinate coil voltage and provide control circuits as required for application.

## 2.5 ELEVATOR SHUNT TRIP SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Bussmann
  - 2. Eaton
  - 3. Littlefuse
  - 4. Mersen
- B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.
- C. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses.
- E. Accessories:
  - 1. Key switch for key-to-test function.
  - 2. Red ON pilot light.
  - 3. Isolated neutral lug.
  - 4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
  - 5. Form C alarm contacts that change state when switch is tripped.
  - 6. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
- F. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

## 2.6 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
  - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  - 2. Outdoor and Wet Locations: NEMA 250, Type 3R.
  - 3. Kitchen and Wash-Down Areas: NEMA 250, Type 3R, stainless steel.
- B. Enclosure Finish: The enclosure shall be finished with the standard manufacturer gray finish.
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Securely fasten each switch and circuit breaker to the supporting structure or wall, utilizing a minimum of four (4) 1/4-inch bolts. Do not mount in an inaccessible location or where the passageway to the switch may become obstructed.
- D. After equipment has been installed, inspected, and is ready to be energized, install fuses in fusible devices in accordance with equipment nameplates and Section 262816, "Fuses".
- E. Comply with NFPA 70 and NECA 1.
- F. Provide electrical interlock kit and low voltage wiring where utilized on the line side of VFD controller to shut down VFD prior to disconnection of power. Coordinate control wire termination with Division 25.
- G. Provide electronic trip breakers where required to achieve performance requirements outlined in Section 260573, "Power Systems Studies".

- H. Provide fusible switches with current limiting fuses or current limiting circuit breaker for equipment disconnecting means where equipment short circuit current rating is insufficient for available fault current.
- I. Where battery lowering devices are specified with Elevators, provide connection between an auxiliary contact at the elevator disconnect and the battery lowering device.
- J. Where enclosed breakers or switched are provided on the load side of a VFD, provide connection between and auxiliary contact at the disconnect and the VFD that will trigger a freewheel stop on the VFD before the disconnect contacts open.

### 3.3 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

### 3.4 IDENTIFICATION

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

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Visual and Mechanical Inspection:
    - a. Examine equipment nameplate data and confirm proper identification.
    - b. Verify and record fuses sizes and types are in accordance with nameplates and power systems study.
    - c. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
    - d. Inspect anchorage, alignment, and grounding.
    - e. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
    - f. Exercise all active components to ensure proper mechanical operation.
    - g. Check all interlocking systems for correct operation.
  - 2. Test ground-fault protection of equipment for service equipment per NFPA 70.
  - 3. Test all auxiliary devices/system interfaces and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

- B. Switches and Circuit Breakers will be considered defective if they do not pass tests and inspections.
- C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Prepare test and inspection reports, including a certified report that identifies switches and circuit breakers included and that describes results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Power System Studies".

END OF SECTION 262816

## SECTION 263213 - DIESEL ENGINE GENERATOR SETS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and **Section 260010 "General Requirements for Electrical Systems"** apply to this Section.

#### 1.2 SUMMARY

- A. **Description: This Section includes packaged engine-generator sets suitable for use in stand-by applications with the features as specified and indicated. The engine generators will be used as the standby power source for the Electrical system but shall be capable of providing reliable power with no run-time limitations while the primary source of power is unavailable.**
- B. Section Includes:
  - 1. Diesel engine.
  - 2. Diesel fuel system.
  - 3. Control and monitoring.
  - 4. Generator overcurrent and fault protection.
  - 5. Generator, exciter, and voltage regulator.
  - 6. Outdoor enclosure.
- C. Related Requirements:
  - 1. Refer to **Section 260500, "Common Work Results for Electrical Systems"** for requirements related to equipment pads.
  - 2. Refer to **Section 263600, "Transfer Switches"** for transfer switches including sensors and relays to initiate automatic-starting and stopping signals for engine generators.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. BMEP: Break Mean Effective Pressure.
  - 2. ECM: Engine Control Module.
  - 3. EPS: Emergency Power Supply.
  - 4. EPSS: Emergency Power Supply System.
- B. Definitions
  - 1. Emergency Standby Power: The maximum power available during a variable electrical power sequence, under the stated operating conditions, for which a generating set is capable of delivering in the event of a utility power outage or under test conditions for up to 200 hours of operation per year with the maintenance intervals and procedures being carried out as prescribed by the manufacturers.

- 
2. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

C. Reference Standards

1. National Electrical Contractors Association (NECA)
  - a. NECA 404, Standard for Installing Generator Sets.
2. National Electrical Manufacturers Association (NEMA)
  - a. NEMA MG 1, Motors and Generators
  - b. NEMA MG2, Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
3. Underwriters Laboratories Inc (UL)
  - a. UL2200, "Standard for Stationary Engine Generator Assemblies".
  - b. UL6200, "Standard for Safety Controllers for Use in Power Production".

1.4 SEQUENCING

- A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in **Section 260573, "Power Systems Studies"**.

1.5 SUBMITTALS

- A. Product Data: Submit for each type of product specified.
1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties, auxiliary components and accessories.
  2. Include thermal damage curve and locked rotor starting curve for generator.
  3. Include time-current characteristic curves for generator protective device.
  4. Include fuel consumption in cubic feet per hour (cubic meters per hour) at 0.8 power factor at 0.5, 0.75-, and 1.0-times generator capacity.
  5. Include generator efficiency at 0.8 power factor at 0.5, 0.75-, and 1.0-times generator capacity.
  6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of ~~95 deg F, 80 deg F, 70 deg F, and 50 deg F~~. Provide drawings showing requirements and limitations for location of air intake and exhausts.
  7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, short-circuit current capability, and transient voltage and frequency response based on project conditions and loads.
  8. Sound test data, based on a free field requirement.
- B. Shop Drawings: Provide the following
1. Include plans and elevations for engine generator and other components specified.
  2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  3. Include details of concrete pad requirements. Indicate layout and stub-up locations for electrical and fuel systems.

4. Identify fluid drain ports and clearance requirements for proper fluid drain.
5. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
6. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
7. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

C. Sample Warranty

D. Qualification Data: For qualified manufacturer and installer.

E. Source quality-control reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified torsional and vibration compatibility complying with NFPA 110.

F. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

G. Closeout Submittals

1. Operation and Maintenance Data: For Generators and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and **Section 260010 "General Requirements for Electrical Systems"**, include the following:
  - a. Operating instructions laminated and mounted adjacent to generator location.
  - b. Maintenance instructions, including lubrication procedures, motor and drive replacement, and spare parts lists.

1.6 MAINTENANCE MATERIAL

- A. Extra Stock Materials: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
  2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
  3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
  4. Tools: Each tool listed by part number in operations and maintenance manual.

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1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer whose products have been in satisfactory use in similar service for not less than 10 years. Certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.
  - 1. Maintain, within 100 miles of Project site, a 24/7/365 service center capable of providing training, parts, maintenance, and emergency repairs to equipment.
  - 2. Employ service technicians specifically trained and certified by the generator set and transfer switch manufacturer.
  - 3. The service center shall maintain a complete inventory of critical power system replacement parts.
  - 4. The manufacturer shall maintain model and serial number records of each transfer switch provided for a minimum of 20 years.
- B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project, with a minimum of 5 years successful installation experience on Projects of similar size and complexity.

1.8 FIELD CONDITIONS

- A. Environmental Conditions: Engine generator system shall withstand the following environmental conditions, while operating under full load, without mechanical or electrical damage or degradation of performance capability. Increase performance ratings for individual system components where indicated herein.
  - 1. Ambient Temperature: 0 deg F (-18 deg C) to 104 deg F (40 deg C).
  - 2. Relative Humidity: 0 to 95 percent.
  - 3. Altitude: Sea level to 1000 feet.

1.9 COORDINATION

- A. Coordinate sizes and locations of concrete bases with dimensions of actual equipment provided.
- B. Equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.
- C. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access and replacement working space requirements of the NEC and Owner.

1.10 WARRANTY

- A. Comprehensive Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and all associated components that fail in materials or



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workmanship within **5 years** from the date of **Substantial Completion**. Comprehensive warranty shall include all parts, supplies, labor, and travel associated with repairs.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
  - 1. Caterpillar
  - 2. Cummins
  - 3. Kohler
  - 4. **MTU**
- B. Source Limitations: Obtain packaged generator sets, transfer switches, and auxiliary components through one source.

### 2.2 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. NFPA Compliance:
  - 1. Comply with NFPA 37.
  - 2. **Comply with NFPA 99.**
  - 3. **Comply with NFPA 101.**
- C. Comply with UL 2200.
- D. NEMA Compliance: Comply with NEMA MG1 and NEMA MG2.
- E. Engine Exhaust Emissions: Comply with EPA requirements and applicable state and local government requirements.
- F. Noise Emissions: Comply with **applicable state and local government requirements** for maximum noise level at **adjacent property boundaries** due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

### 2.3 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine generator and accessories.
- B. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. **Rigging Diagram: Indicate location and lifting capacity of each lifting attachment, generator-set center of gravity, and total package weight.**

C. Capacities and Characteristics:

1. Power Output: Nominal rating as indicated on drawings for continuous standby operation, at 0.8 lagging power factor, excluding power required for the continued and repeated operation of the unit and accessories.
2. Voltage and Phase: As indicated on drawings.
3. Frequency: 60 Hz.
4. Alternator shall be capable of accepting **loads indicated on drawings** in a single step ~~and be capable of recovering to a minimum of 90% of rated no load voltage. Following the application of the specified kVA load at near zero power factor applied to the generator set.~~
5. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components. The engine-generator nameplate shall include information of the power output rating of the equipment.

A. Generator Set Performance

1. Steady-State Voltage Operational Bandwidth: **2.5 percent** of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than **25 percent** rise during 100% load decrease and not more than **20 percent** dip during BMEP step load increase. Voltage shall recover and remain within the steady-state operating band within **6 seconds**.
3. Steady-State Frequency Operational Bandwidth: **1.5 percent** of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Not more than **12 percent** rise during 100% load decrease and not more than **10 percent** dip during BEMP step load increase. Frequency shall recover and remain within the steady-state operating band within **5 seconds**.
6. Output Waveform: At full load, harmonic content measured line to line or line to neutral shall not exceed **5 percent** total and **3 percent** for any single harmonic. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of **250 percent** of rated full-load current for not less than **10 seconds** and then clear the fault automatically, without damage to generator system components. For a 1-phase bolted short circuit at system output terminals, system shall regulate both voltage and current to prevent over-voltage conditions on the non-faulted phases.
8. Start Time: Comply with NFPA 110, **Level 1, Type 10**, system requirements.
9. Noise Output: Engine generator shall be tested by the manufacturer per ANSI S12.34.

2.4 DIESEL ENGINE

- A. Fuel: ASTM D975, #2 diesel fuel.
- B. Rated Engine Speed: 1800 RPM.

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- C. Lubrication System: Engine or Skid mounted.
1. Lube oil pump: positive displacement, mechanical, full pressure pump.
  2. Filter and Strainer: Provided by the engine manufacturer to provide adequate filtration for the prime mover to be used. Replaceable spin-on filters and dipstick oil level indicator.
  3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- D. Governor: Adjustable isochronous, with speed sensing. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate as appropriate to the state of the engine generator. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous states. The governor control shall be suitable for use in future paralleling applications without component changes.
- E. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Size as recommended by manufacturer to comply with NFPA 110 requirements for **Level 1** equipment and with UL 499 for heater capacity and performance.
1. Designed for operation on a single 120VAC or 208VAC, Single phase, 60Hz power connection.
  2. Installed with isolation valves and quick disconnect couplers to isolate the heater for replacement of the element without draining the engine cooling system or significant coolant loss.
  3. Provided with a 24VDC thermostat, installed at the engine thermostat housing.
- F. Cooling System: Closed loop, liquid cooled, skid mounted radiator.
1. Prototype tested with specific hardware proposed demonstrating the assembly can operate at rated standby load in an outdoor ambient condition up to **50 deg C**.
  2. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  3. Size of Radiator Overflow Tank: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
  4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
  5. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
  6. Coolant Hose: Flexible silicone assembly with aging-, UV-, and abrasion-resistant cover. Provide steel tubing for connections to the engine coolant system wherever the length of the pipe run exceeds 12 inches.
- G. Muffler/Silencer: Minimum **critical grade** with a minimum sound attenuation of **25dB at 500Hz**, sized as recommended by engine manufacturer, selected to meet sound performance requirements of the application, and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements. Located inside the housing enclosure unless noted otherwise.
1. Mounted so that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine.

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- H. Air-Intake Filter: Engine-mounted air cleaner with replaceable dry-filter element and restriction indicator.
- I. Starting System: 24VDC electric, as recommended by the engine manufacturer to meet system performance requirements; with negative ground.
1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Environmental Conditions" Article.
  2. Cranking Cycle: As required by NFPA 110 for system level specified. Capable of either one 45 second continuous cranking cycle or three 15 second cranking cycles with 15 second rest between without overheating.
  3. Battery: Lead Acid type, 24-volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors.
  4. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
  5. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation.
  6. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation. The battery charging alternator shall have sufficient capacity to recharge the batteries with all parasitic loads connected within 4 hours after a normal engine starting sequence.
  7. Battery Charger: Fully regulated, constant voltage, current limited, battery charger for each battery bank. Comply with NFPA 110, UL 1236, and include the following features:
    - a. Operation: Equalizing-charging rate based on generator set manufacturer's recommendations shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 20 deg C to plus 40 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    - d. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    - e. Provide LED indication of general charger condition, including charging, faults, and modes. Provide a LCD display to indicate charge rate and battery voltage. Charger shall provide relay contacts for fault conditions as required by NFPA110.
    - f. Enclosure and Mounting: NEMA, Type 1, cabinet.
    - g. Charger shall include an Analog DC voltmeter and ammeter, 12-hour equalize charge timer, and AC and DC fuses. Operational monitors shall provide visual output along with individual form C contacts for remote indication of:
      - 1) Loss of AC power - red light
      - 2) Low battery voltage - red light
      - 3) High battery voltage - red light
      - 4) Power ON - green light (no relay contact)

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## 2.5 DIESEL FUEL-OIL SYSTEM

- A. Fuel: ULSD Diesel #2 ASTM D975.
- B. Comply with NFPA 30 and NFPA 37.
- C. Engine Fuel System: The engine fuel system shall be installed in strict compliance to the engine manufacturer's instructions.
- D. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions. Engine driven, mechanical, positive displacement fuel pump.
- E. Fuel Filtering: Replaceable spin-on canister element with water separator.
- F. Fuel Cooler: Suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.
- G. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- H. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with **UL 142** fuel-oil tank. Features include the following:
  - 1. Electrical stub up(s).
  - 2. Mechanical fuel level gauge: Direct reading, UL-listed, magnetic with a hermetically sealed, vacuum tested dial.
  - 3. High and low fuel level indicators.
  - 4. Low Fuel Alarm Contacts: for annunciation of a low fuel condition.
  - 5. Provide means to prevent overfilling by sounding an alarm when the liquid level in the tank reaches 90 percent of capacity and by automatically stopping delivery of liquid to the tank when the liquid level in the tank reaches 95 percent of capacity.
  - 6. Normal and emergency relief vents: for inner and outer tank, UL-listed, sized in accordance with American Petroleum Institute Standard No 2000.
  - 7. Fuel-Tank Capacity: ~~Minimum 133 percent of total fuel required for planned operation plus fuel for periodic maintenance operations between fuel refills.~~ Minimum 133 percent of total fuel recommended by engine manufacturer for an uninterrupted period of **24** hours operation at full load without being refueled. Comply with NFPA 110.
  - 8. Containment basin: Welded steel, sized at a minimum of **130 percent** of the tank capacity to prevent escape of fuel into the environment in the event of a tank rupture.
  - 9. Monitored leak detection in interstitial space.
  - 10. Lockable vandal-resistant fill cap.
  - 11. Fill port with overfill prevention valve and spill containment.
  - 12. Integral lifting provisions.
  - 13. Comply with requirements of authorities having jurisdiction.
  - 14. Other requirements**

## 2.6 CONTROL AND MONITORING

- A. Provide microprocessor-based engine generator control with automatic starting, monitoring, protection and control functions for the unit.

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- B. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. Switches with different configurations but equal functions are acceptable. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of the local, generator set-mounted, and/or remote emergency-stop switch also shuts down generator set.
- C. Manual Starting System Sequence of Operation: Switching On-Off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms. Operation of the local, generator set-mounted, and/or remote emergency-stop switch also shuts down generator set.
- D. Comply with UL 508A or UL6200.
- E. Configuration: Operating and safety indications, protective devices, system controls, engine gages and associated equipment shall be grouped in a common control and monitoring panel. Mounting method shall isolate the control panel from generator-set vibration. AC output power circuit breakers and other output power equipment shall not be mounted in the control enclosure.
- F. Control and Monitoring Panel
1. Digital controller with integrated graphical display, navigational devices, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup. Capable of viewing all engine status and alarm/shutdown conditions. Include integrated provisions for adjustment of the gain and stability settings for the governing and voltage regulation systems.
  2. Instruments and Digital Metering: Located on the control and monitoring panel and viewable during operation. Ammeter-voltmeter displays shall simultaneously display conditions for all three phases.
    - a. Engine lubricating-oil pressure gage.
    - b. Engine-coolant temperature gage.
    - c. DC voltmeter (alternator battery charging).
    - d. Running-time meter.
    - e. AC voltmeter (3-phase, line to line and line to neutral values).
    - f. AC ammeter (3-phases).
    - g. AC frequency meter.
    - h. AC kW and kVA output (total and for each phase). Display shall indicate power flow direction.
    - i. AC Power factor (total and for each phase). Display shall indicate leading or lagging condition.
    - j. Generator-voltage and frequency digital raise/lower switches. Rheostats for these functions are not acceptable. The control shall adjustment of these parameters in a range of plus or minus 5% of the voltage and frequency operating set point (not nominal voltage and frequency values).

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3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level indicated, including the following:
- a. Run-Off-Auto Switch: The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
  - b. Include adjustable time delay start and time delay stop functions.
  - c. Emergency Stop Switch: Switch shall be a red “mushroom head” pushbutton device complete with lock-out/tag-out provisions. Depressing switch shall cause the generator set to immediately stop the generator set and prevent it from operating or automatically restarting.
  - d. Fault Reset Switch: Supply a dedicated control switch to reset/clear fault conditions.
  - e. AC Protective Equipment: The control system shall include over/under voltage, over current, short circuit, loss of voltage reference, and over excitation shut down protection. There shall be an overload warning, and overcurrent warning alarm. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
  - f. Status LED indicating lamps to indicate remote start signal present at the control, existing alarm condition, not in auto, and generator set running.
  - g. Include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure condition.
  - h. Integrated provisions for adjustment of the gain and stability settings for the governing and voltage regulation systems.
  - i. Cycle cranking control: Allow for user selected crank time, rest time, and number of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.
  - j. Idle Mode Control: allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
  - k. Panel lighting system to allow viewing and operation of the control when the generator room or enclosure is not lit.
  - l. DC control Power Monitoring: The control system shall continuously monitor DC power supply to the control, and annunciate low or high voltage conditions. It shall also provide an alarm indicating imminent failure of the battery bank based on degraded voltage recover on loading (engine cranking). During engine cranking (starter engaged), the low voltage limit shall be disabled.
  - m. Fuel tank derangement alarm.
  - n. Fuel tank high-level shutdown of fuel supply alarm.
  - o. Lamp test: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
  - p. Provide provisions for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall

be of the same type and quality as the above specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

4. Data Logging: The control system shall log the latest 20 different alarm and shut down conditions, the total number of times each alarm or shutdown has occurred, and the date and time the latest of these shutdown and fault conditions occurred.

**G. Connection to Building Automation**

1. A separate terminal block, factory wired to minimum four Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via BACnet-IP. Refer to HVAC Control Specifications and Points List for values to be reported and coordination of communications protocol. At a minimum, include all NFPA-110 required alarms, complete power and voltage data (per phase and three phase), basic engine, fuel, and lubricant system status and alarms, and all functions common to the system Generator Alarm Annunciator(s).
3. Allow for remote sequencing and operation of mechanical equipment when unit is running. Coordinate exact requirements with mechanical contractor and provide complete interface as required.

- H. Remote Alarm Annunciator: Comply with NFPA 110. A LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. Provide number and location per plans and all necessary wiring and connections. Remote annunciators shall be powered from the engine generator battery.

- I. Start Circuit Monitoring Provide engine start circuit monitor to continuously monitor the integrity of the generator control wiring. Loss of integrity of the remote start circuit(s) through and open or short fault shall initiate visual and audible annunciation of generator malfunction at the generator local and remote annunciator(s) and simultaneously start the generator(s) to ensure fail safe operation.

- J. Control Heater: Generator sets that are installed in outdoor enclosures shall be provided with control heaters for anti-condensation protection.

- K. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation. Locate adjacent to automatic transfer switch served from the generator and as indicated on plans.

**2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION**

- A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
1. Tripping Characteristics: Adjustable long-time, short-time, and instantaneous delay.



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2. Trip Settings: Selected to coordinate with generator thermal damage curve.
  3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
  4. Mounting: Adjacent to or integrated with control and monitoring panel. Isolated from vibrations induced by the generator set.
  5. Mechanical type lugs, sized for the conductors shown on drawing, shall be supplied on the load side of breaker.
  6. Provide arc energy reduction maintenance switch for all overcurrent protective devices rated 1200 amps or greater or where the continuous current trip setting can be adjusted to 1200A or greater.
- C. Generator Protector: Provide a UL6200 certified protective device, coordinated with the alternator, to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine. The protective device shall be listed as a utility grade protective device under UL category NRGU. Protector performs the following functions:
1. Initiates a generator kW overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
  2. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110% of rated current for more than 10 seconds.
  3. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator.
  4. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.
  5. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120% of nominal voltage.
  6. The protective system provided shall not include an instantaneous trip function.
  7. The protective system shall fully protect the alternator's thermal damage curve.
  8. Include load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
- D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.
1. The control System shall include a ground fault monitoring relay. The relay shall be adjustable and include an adjustable time delay. The relay shall be for indication only, and not trip or shut down the generator set. Coordinate with system grounding and bonding arrangement, and provide relay that will function correctly in system as installed.
- 2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR
- A. Comply with NEMA MG 1.
  - B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
  - C. Electrical Insulation: Class H
  - D. Temperature Rise: Maximum 125 deg C for 40 deg C ambient.

- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over speed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Permanent Magnet Generator (PMG) shall provide excitation power for optimum motor starting and short circuit performance.
- G. Enclosure: Drip-proof.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110. The voltage regulation system shall be microprocessor-controlled, full wave rectified, and provide a pulse-width modulated signal to the exciter. No exceptions or deviations to these requirements will be permitted.
- I. **The alternator shall be provided with anti-condensation strip heater in all applications where the generator set is provided in an outdoor enclosure to maintain windings above dew point.**
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent maximum, based on the rating of the engine generator set.

## 2.9 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weather protected **steel** housing, wind resistant up to **150** mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Instruments, control, and battery system shall be mounted within enclosure.
  - 1. **Sound Attenuation Level: maximum of 75 dBA measured during full load at 7 meters in a free field environment with a vertical radiator discharge.**
- B. Hinged Doors: With padlocking provisions. Restraint/Hold back hardware to prevent door to keep door open at 180 degrees during maintenance. Rain lips over all doors.
- C. Insulation: Non-hygroscopic materials as recommended by Manufacturer to comply with thermal and acoustic performance requirements.
- D. Provide enclosure to allow the generator set to operate at full rated load with a static pressure drop equal to or less than 0.5 inches of water.
- E. Muffler and Silencer: Located within enclosure. Include a raincap and rainshield.
- F. Hardware: Corrosion resistant stainless steel.
- G. Mounting Base: Suitable for mounting on housekeeping pad.
- H. Include rain hoods for air inlets.
- I. Lifting: Complete assembly of engine generator, enclosure shall be designed to be lifted into place as a single unit, using spreader bars:

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- J. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
  - K. Operable Dampers: At enclosure air intake and discharge, provide operable dampers that close when unit is not operating. Comply with NFPA 110 to maintain required ambient air temperature in the housing. Provide “fail open” design to allow airflow in the event of failure..
  - L. Include flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves.
  - M. Where center of circuit breaker handles, switch handles, or controller interface is located more than 6-foot, 7-inches above ground level or equipment pad, provide an aluminum service access platform. The platform shall be the width of the serviceable openings and shall have stairs up to the platform. Provide protective railing around platform with access stairs. Platform assembly shall comply with OSHA requirements. Increase equipment pad size as necessary to accommodate service access platform.

## 2.10 VIBRATION ISOLATION DEVICES

- A. Provide generators with elastomeric isolator pads integral to the generator, unless the engine manufacturer requires use of spring isolation.

## 2.11 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Powder-coated and baked over corrosion-resistant pretreatment and compatible primer. Manufacturer’s standard color unless indicated otherwise on the drawings.

## 2.12 SOURCE QUALITY CONTROL

- A. Prototype Testing: Test engine-generator set as a complete assembled unit using same engine model, constructed of identical or equivalent components, and equipped with identical or equivalent accessories.
  - 1. Tests: Comply with NFPA 110, **Level 1** Energy Converters.
  - 2. In addition, validate the capability of the design under the abnormal conditions noted in NFPA 110 by subjecting the equipment engine, skid, cooling system, and alternator to actual prototype tests. Calculations and testing on similar equipment which are allowed under NFPA 110 are not sufficient to meet this requirement.
    - a. Include vibration testing conducted to validate the integrity and prolonged health of the generator assembly.
    - b. Verify the torsional compatibility of the rotating equipment.
- B. Factory Tests and Inspection: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

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1. Test generator, exciter, and voltage regulator as a unit to demonstrate compatibility and functionality.
  2. Start-up testing.
  3. Load Test at 25, 50, 75, and 100 percent load at rated power factor.
  4. Maximum power.
  5. Voltage regulation.
  6. Transient and steady-state governing at no load and full load.
  7. Single-step full load pickup.
  8. Simulated safety shutdowns.
- C. Product will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports. Report factory test results within 10 days of completion of test.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
- B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.
- C. Physically inspect equipment for damage. Repair scratches and other installation damage prior to final system testing. Thoroughly clean equipment to remove all dirt and construction debris prior to initial operation and final testing of the system.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 404.
- B. Comply with packaged engine generator manufacturers' written installation, application, and alignment instructions and with NFPA 70 and NFPA 110.
- C. Equipment Mounting:
  1. Install packaged engine generators and any access platforms on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in **Section 260500, "Common Work Results for Electrical Systems"**.
  2. Coordinate size and location of concrete bases for packaged engine generators and any access platforms.
  3. Install units on vibration isolators in accordance with manufacturer's recommendations.
  4. Permanently fasten equipment to the pad in accordance with the manufacturer's instructions **and seismic criteria of the Project.**

- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe, the full size of the drain connection, with welded joints.
- F. Fuel Piping: Comply with **Division 23** for fuel piping, valves, and specialties for fuel distribution.
- G. Install electrical devices and components that are not factory mounted.
- H. Provide all interconnection wiring between system components and equipment.

### 3.3 CONNECTIONS

- A. Coordinate with all trades for generator interface with other building systems.
- B. Provide flexible connections for all connections to the generator and between its components to reduce vibrations transmitted to surrounding structures.
- C. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Fuel Connections:
  - 1. Comply with manufacturer's instructions.
  - 2. Connect fuel piping to engines with a gate valve and union and flexible connector.
  - 3. Install manual shutoff valve in a remote location to isolate fuel supply to the generator.
  - 4. Vent gas pressure regulators outside building a minimum of **60 inches** from building openings.
- F. Provide raceways for all wiring according to **Section 260533 "Raceways and Boxes for Electrical Systems."**
- G. Install and connect wiring according to **Section 260519 "Low-Voltage Electrical Power Conductors and Cables."**
  - 1. Provide Class D extra flexible stranded conductors for all connections to genset
  - 2. Control conductors installed between the transfer equipment and the emergency generator shall be kept entirely independent of all other wiring in accordance with NEC.
- H. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

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- I. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

### 3.4 GROUNDING

- A. Ground and bond equipment according to **Section 260526 "Grounding and Bonding for Electrical Systems."**
  1. Install a minimum of two auxiliary grounding electrodes at outdoor generator locations. Connect the electrodes to the equipment grounding conductor and to the frame of the generator in accordance with the generator manufacturer's recommendations.
  2. If the grounded neutral conductor is switched at a 4-pole transfer switch, provide a main bonding jumper between the generator's grounded terminal (neutral) and the equipment grounding terminal.

### 3.5 IDENTIFICATION

- A. Comply with requirements in **Section 260553, "Identification for Electrical Systems".**
  1. For non-separately derived systems, install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

### 3.6 ADJUSTING

- A. Set field-adjustable circuit-breaker trip ranges and time delay settings to recommended values identified in the final approved power system study.

### 3.7 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to perform start-up and testing.
- B. The factory-authorized service representative shall perform a site evaluation prior to test and inspections to verify the equipment is installed in accordance with the manufacturer's instructions. Equipment shall be initially started and operated by the authorized service representative.
- C. Provide 7-day advance notice of any testing to allow The Engineer and Owner's Representative the option to witness the tests.
- D. Provide fuel, engine fluids, and load bank required for testing and commissioning of the engine generator. At completion of the testing, completely fill all fuel tanks in accordance with manufacturer's recommendations prior to system turn-over.
- E. Pre-Operational Tests and Inspections
  1. Visual and Mechanical Inspection:
    - a. Examine equipment nameplate data and confirm proper identification.

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- b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
  - c. Inspect anchorage, alignment, and grounding and verify items are in accordance with manufacturer's published data.
  - d. Verify the unit is clean.
  - e. Inspect bolted electrical connections and terminations for high resistance by verifying tightness with calibrated torque-wrench method in accordance with manufacturer's published data.
  - f. Exercise all active components.
  - g. Inspect all mechanical indicating devices for correct operation.
  - h. Physically test key interlock systems to check for proper functionality prior to energizing.
2. Electrical and Mechanical Tests:
- a. Perform insulation-resistance tests in accordance with IEEE 43.
    - 1) Machines larger than 200 hp. Test duration shall be 10 minutes. Calculate polarization index and verify value is not less than 2.0.
    - 2) Machines 200 hp or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio and verify value is not greater than 1.0.
  - b. Test protective relay devices.
  - c. Verify phase rotation, phasing, and synchronized operation comply with system performance requirements.
  - d. Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
  - e. Verify correct functioning of the governor and regulator.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment in accordance with manufacturer's recommendations.
- G. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- H. Functional Acceptance Testing:
- 1. Test the complete automatic transfer switch system and generator control system concurrently to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
  - 2. Provide the following documentation at the time of the acceptance testing:
    - a. Evidence of prototype testing.
    - b. Certified analysis verifying the torsional vibration compatibility of the rotating element of the prime mover and generator for the intended use.
    - c. Letter of compliance verifying installation complies with the applicable version on NFPA 110, in its entirety.
    - d. Manufacturer's certification of a rated load test at rated power factor with the ambient temperature, altitude, and fuel grade recorded.
  - 3. Where tests are performed sequentially, allow the generator to cool for at least 30 minutes between tests.
  - 4. In the presence of the AHJ, perform tests required by NFPA 110, in addition to those specified herein, to demonstrate standby capability and compliance with requirements.

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- a. Cold Start Test: With the engine generator in a cold start condition, demonstrate the engine generator set will maintain proper voltage and frequency within the specified time limits under the normal operating load of the building for a duration of 2 hours.
  - b. Full Load Test: Using a multi-stage resistive load bank to supplement building load equal to 100 percent of the nameplate kW ratings, perform full load run test for a duration of 2 hours.
  - c. Cycle Crank Test: Perform the cycle crank test per the manufacturer's recommendations. Verify and record the battery charge rate at 5-minute intervals for the first 15 minutes or until charge rate stabilization.
  - d. Test all safeties, protections, remote controls, and alarms as required per NFPA 110. Factory tests may be substituted for on-site tests only where specifically permitted by NFPA 110.
5. In new construction or unoccupied buildings, initiate testing by opening the main normal power service disconnecting means to simulate utility power failure. In existing or occupied buildings, initiate testing by opening the normal power feeder breakers to all transfer switches. Coordinate timing and obtain approval for start of test with site personnel.
6. **Transient Test: Verify voltage and frequency deviations are within acceptable limits while adding and dropping each step load.**
- a. **Verify ability to allow starting and running the largest motor load at its full load current rating while supplying all other simultaneous loads.**
7. Record all operating parameters and conditions as required per NFPA 110, including the following:
- a. Fuel level at start and finish.
  - b. Time delay on start.
  - c. Engine cranking time, from start signal to running.
  - d. Time taken to reach engine rated operating speed.
  - e. Time taken to reach steady state condition with all transfer switches in emergency position.
  - f. All transfer switch time delays for each transfer switch, including time in normal position after start, time at center-off position, total time from normal to emergency, time delay to retransfer to normal.
  - g. Engine cooldown time (unloaded running time after last transfer switch is in normal position).
  - h. Total test runtime and total engine operating hours.
  - i. Record the following values at first load acceptance and at 15 minute intervals thereafter for the duration of the testing:
    - 1) Output voltage (each phase), output current (each phase), kW, and KVA.
    - 2) Coolant temperature.
    - 3) Lube oil pressure.
- I. Ensure test instruments have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- J. Products will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.



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- K. Correct deficiencies identified by tests and observations and retest until specified requirements are met.
  - L. Report results of tests and inspections in writing. Record adjustable settings, measured values, and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

### 3.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by the manufacturer service manual and any calibration required for proper operation. Include emergency service. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

### 3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.
- B. Training shall consist of not less than **six hours** of hands-on instruction for a minimum of four attendees. Training shall cover the following topics at a minimum:
  - 1. Theory of operation
  - 2. Operation of Generator and components
  - 3. Maintenance and configuration
  - 4. Troubleshooting and Repair
  - 5. Replacement of components.

END OF SECTION 263213

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## SECTION 263600 - TRANSFER SWITCHES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01 Specification Sections, and **Section 260010 "General Requirements for Electrical Systems"** apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Automatic Transfer Switch
  - 2. **Bypass/Isolation Switch**
  - 3. Portable Generator Docking Station
- B. Related Requirements:
  - 1. **Refer to Section 263213, "Engine Generator Sets" for requirements related to packaged engine generator sets.**

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. EPS: Emergency Power Supply.
  - 2. EPSS: Emergency Power Supply System.
- B. Reference Standards
  - 1. National Electrical Contractors Association (NECA)
    - a. NECA 404, "Standard for Installing Generator Sets"
  - 2. National Electrical Manufacturers Association (NEMA)
    - a. NEMA ICS 1, "Industrial Control and Systems General Requirements"
    - b. NEMA ICS 10, "Industrial Control and Systems: Transfer Switch Equipment"
  - 3. Underwriters Laboratories Inc (UL)
    - a. UL1008, "Transfer Switch Equipment".

#### 1.4 SEQUENCING

- A. Submit the preliminary power system study prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. Adjust equipment sizes, frame sizes, and trip units as necessary to achieve performance requirements outlined in **Section 260573, "Power Systems Studies"**.

## 1.5 SUBMITTALS

- A. Product Data: Submit for each type of product specified.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
  - 2. Include rated capacities, weights, operating characteristics, electrical characteristics, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
  - 2. Include material lists for each switch specified.
  - 3. Wiring Diagrams: Show connections between transfer switch, power sources, loads, and show any interlocking provisions.
  - 4. Interconnection Diagrams: Show interconnection wiring between transfer switches, generators, annunciators, and control panels. Indicate recommended conduit runs and point-to-point terminal connections.
- C. Qualification Data: For qualified manufacturer, installer, and qualified service representative.
- D. Closeout Submittals
  - 1. Operation and Maintenance Data: For Generators and components to include in operation and maintenance manuals.
  - 2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Features and operating sequences, both automatic and manual.
    - b. List of all factory settings and calibration instructions, including software, where applicable.
    - c. Factory test reports.

## 1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer whose products have been in satisfactory use in similar service for not less than 10 years. Certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.
  - 1. Maintain, within 100 miles of Project site, a 24/7/365 service center capable of providing training, parts, maintenance, and emergency repairs to equipment.
  - 2. Employ service technicians specifically trained and certified by the generator set and transfer switch manufacturer.
  - 3. The service center shall maintain a complete inventory of critical power system replacement parts.
  - 4. The manufacturer shall maintain model and serial number records of each transfer switch provided for a minimum of 20 years.

- B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project, with a minimum of 5 years successful installation experience on Projects of similar size and complexity.

## 1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with dimensions of actual equipment provided.
- B. Equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.
- C. Drawings indicate space available for electrical equipment, including clearances between equipment and adjacent surfaces and other items. Equipment installed must comply with all clearance, access and replacement working space requirements of the NEC and Owner

## 1.8 WARRANTY

- A. Comprehensive Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch and all associated components that fail in materials or workmanship within **5 years of Substantial Completion**. Include all parts, supplies, labor, and travel associated with repairs with no deductibles.
- B. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility for products provided.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to the authority having jurisdiction, and marked for intended location and application.
  - 1. Automatic Transfer Switches: listed and marked for emergency use.
- B. **Provide transfer switches that are constructed and third party certified to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."**
- C. NFPA Compliance:
  - 1. Comply with NFPA 70. Equipment shall be suitable for use in systems in compliance with Articles 700, 701, and 702.
  - 2. **Comply with NFPA 99.**
  - 3. Comply with NFPA 110
- D. Comply with UL 1008.

- E. NEMA Compliance: Comply with NEMA ICS 1 and ICS 10.
- F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.
- G. Fault-Current Withstand and Closing Ratings (WCR: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008. UL 1008 WCR ratings must be specifically listed as meeting the requirements for a specific time duration or for use with a specific overcurrent protective device, under specified fault conditions. Base WCR on use of the same set of contacts for the withstand test and the closing test.
  - 1. Short Circuit WCR time duration: 0.05 seconds (3 cycles at 60 Hz).
  - 2. Short-time WCR time duration: 0.5 seconds (30 cycles at 60 Hz).
- H. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- I. Start Circuit Monitoring: Provide engine start circuit monitor to continuously monitor the integrity of the generator remote start circuit. Loss of integrity of the remote start circuit(s) through broken, disconnected, or shorted wires shall initiate start the generator(s) to ensure fail safe operation.
- J. Enclosure: Surface or Floor mounted, Certified for compliance to NEMA ICS 6 and UL 508.
  - 1. Rated for environmental conditions at installed location.
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    - b. Outdoor and Wet Locations: NEMA 250, Type 3R.
    - c. Corrosive Environments: NEMA 250, Type 4X.
  - 2. Hinged door with permanently mounted key-type latches. All lock assemblies shall be keyed alike.
  - 3. Finish: Factory-applied finish in manufacturer's standard color over a rust-inhibiting primer on treated metal surface.
  - 4. Comply with minimum wire bending space requirements in accordance with NEC, regardless of conduit entry direction.
  - 5. Provide pull section where required for bottom fed, front accessible only installations.
- K. Service Entrance Rated Transfer Switch:
  - 1. Comply with UL 869A and UL 489.
  - 2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
  - 3. Provide the bonding connection on the neutral bus for systems with a neutral.
  - 4. Provide removable link for temporary separation of the service and load grounded conductors.
  - 5. Provide surge protective device in accordance with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
  - 6. Service Disconnecting Means: Externally operated, manual actuated circuit breaker, molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

- a. Tripping Characteristics: Adjustable long-time, short-time, instantaneous delay, and ground fault.
- b. Provide equipment ground fault protection for all overcurrent protective devices 1000 amps or greater on 480Y/277V systems.
- c. Provide arc energy reduction maintenance switch for all overcurrent protective devices rated 1200 amps or greater or where the continuous current trip setting can be adjusted to 1200A or greater.

## 2.2 AUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide product from one of the following:
  1. Asco 300 Series
  2. Cummins
  3. Russelectric RTSCD
- B. Source Limitations: Obtain packaged generator sets, automatic transfer switches and auxiliary components through one source.
- C. Switch Characteristics: Contactor type, designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  1. Limitations: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable unless noted otherwise.
  2. Switch Action: Double throw; mechanically held in both directions.
  3. Switch Contacts:
    - a. Silver composition or High-pressure silver alloy for load-current switching.
    - b. Provide contact assemblies with arc chutes for positive arc extinguishing. Include insulating covers to prevent inter-phase flashover.
    - c. Encapsulate contacts to increase phase-to-phase isolation and reduce the possibility of arcing between phases.
    - d. Positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
    - e. Provide switches rated 150A and higher, with segmented blow-on construction and separate arcing contacts.
  4. Contacts operated by a high-speed electrical mechanism that causes contacts to open or close within three electrical cycles from signal.
  5. Conductor Connectors: Suitable for use with conductor material and sizes.
  6. Material: Hard-drawn copper, 98 percent conductivity.
  7. Main, Neutral, and Ground Lugs: Mechanical type, suitable for the material, number, and size of conductors indicated on the drawings.
  8. Bus-Configured Terminators: Mechanical type.
  9. Connectors shall be marked for conductor size and type according to UL 1008.
  10. Manual Switch Operation: Manual, non-electric operation, for service use only under no-load conditions with the enclosure door open. Control circuit automatically disconnects from electrical operator during manual operation. Provide permanently attached manual operating handles.

- D. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism.
- E. Factory Wiring: Internal wiring composed of premanufactured harnesses that are permanently marked for source and destination. Connected to control system by means of locking disconnect plug(s), to allow control system to be easily disconnected and serviced without disconnecting power from transfer switch mechanism.
- F. Field Control Wiring Interconnections: Screw type terminal blocks, appropriate for field wiring, clearly and permanently labeled.
- G. Neutral Switching: As indicated on drawings
  - 1. For transfer switches indicated as 4-pole, provide a switched neutral pole with the same ratings and matching construction as the phase poles. All poles shall be switched simultaneously using a common crossbar. Use of overlapping neutral contacts is not acceptable.
  - 2. For transfer switches indicated as 3-pole, provide a solid neutral bus and lugs. Size the neutral bus to carry 100 percent of the current designated on the switch rating.
- H. Automatic Open/In-Phase Transition Transfer Switches: High Speed transition occurs with no intentional time delay but waits for source phase, voltage, and frequency to synchronize.
  - 1. Mechanically and electrically interlock sources to prevent closing both sources on the load at the same time.
- I. Electromechanical Non-Automatic Switch Operation: Requires user action to operate transfer switch using manual selector switches.
  - 1. Electrically actuated by push buttons designated "Normal Source" and "Alternative Source" and coordinated with control function.
  - 2. Capable of transferring load in either direction with either or both sources energized, under load, and with enclosure door closed.
- J. Communication Interface Integrated communication capability with the following minimum interfaces:
  - 1. One RS485 serial communication port and two TCP/IP Ethernet ports for interface with a network of generator controller(s), transfer switch(es), annunciator(s), and other remote programming devices.
  - 2. One USB communication port for PC service interface.
- K. Automatic Transfer-Switch Controller Features:
  - 1. Microprocessor based, password protected, sealed membrane LCD digital display mounted on and operational from enclosure door, with integral pushbuttons and LED status indicators.
    - a. All settings shall be configurable locally through display or remotely through PC based service tool interfaced with serial communications port. DIP switches or other electromechanical devices are unacceptable.
  - 2. Power Supply: Powered from available sources and generator set battery. Capable of operating through a loss of control power. Field configurable for any operating voltage level up to 600 VAC.



- a. Provide integrated DC power supply with the ability to automatically switch between isolated inputs and utilize best available DC source.
  - b. Incorporate non-volatile memory. Should power be interrupted and subsequently restored, control settings and parameters saved in protected memory shall not be lost and should restore system to its last operating state without requiring user input.
3. Comply with or exceed the following requirements for Electromagnetic Compatibility (EMC):
  - a. EN 61000-6-2 Generic standards: Immunity for industrial environments.
  - b. EN 61000-4-2 Electrostatic Discharge Immunity.
  - c. EN 61000-4-3 Radiated, radio-frequency, electromagnetic field immunity.
  - d. EN 61000-4-4 Electrical fast transient/burst immunity.
  - e. EN 61000-4-5 Surge immunity
  - f. EN 61000-4-6 Conducted Immunity.
  - g. EN 61000-4-8 Power Frequency Magnetic Field.
4. Voltage, **Current**, Frequency, and Phase Rotation Sensing: for both normal and emergency sources, continuously monitored, on all three phases, without external transformers, field adjustable in 1 percent increments.
  - a. Undervoltage:
    - 1) Pickup: 85 to 100 percent of nominal.
    - 2) Dropout: 75 to 98 percent of nominal.
    - 3) Dropout Time Delay: 0.1 to 1.0 seconds
  - b. Overvoltage:
    - 1) Pickup: 95 to 99 percent of dropout
    - 2) Dropout: 105 to 135 percent of nominal
    - 3) Dropout Time Delay: 0.5 to 120.0 seconds
  - c. Over- and Under- frequency
    - 1) Pickup: plus or minus 5 to 20 percent of nominal
    - 2) Dropout: plus or minus 1 percent beyond pickup
    - 3) Dropout Time Delay: 0.1 to 15.0 seconds
  - d. Voltage Imbalance
    - 1) Pickup: 90 percent of dropout
    - 2) Dropout: 2 to 10 percent
    - 3) Time Delay: 2.0 to 20.0 seconds
  - e. **High Neutral Current**
    - 1) **Pickup: 100 to 150 percent of nominal.**
    - 2) **Warning Delay: 10 to 60 seconds.**
  - f. Phase Loss and Phase Rotation.
    - 1) Time Delay: 100 milli-seconds
5. Built-in, Adjustable Time Delays:
  - a. Engine Start: 0 to 120 seconds.
  - b. Transfer to Emergency Source: 0 to 120 seconds.
  - c. Retransfer to Normal Source: 0 to 30 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
  - d. Engine Stop/Cooldown: 0 to 30 minutes.
  - e. Programmed/Delayed Transition (where specified): 0 to 600 seconds.
6. LED Indicating Lights:
  - a. Switch-Position: Indicate source to which load is connected.

- b. Source-Available: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
  - 1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
  - 2) Emergency Power Supervision: Red or yellow light with nameplate engraved "Emergency Source Available."
- c. Switch set to non-automatic operation.
- d. Control disabled.
- e. Switch in test/exercise mode.
- 7. Pushbutton Switches:
  - a. Test Switch: Activates or cancels preprogrammed test sequence to simulate normal-source failure with or without load.
  - b. Override Switch: Override any programmed time delays for engine start, transfer, and retransfer, and immediately go to the next operation.
  - c. Fault Reset Switch: Dedicated control switch to reset/clear fault conditions.
  - d. Lamp Test Switch: Simultaneously illuminates all panel LEDs.
- 8. Digital Display: UV protected, color, alphanumeric, capable of recording and displaying the following information:
  - a. Real time power data for each phase and source.
  - b. Real time clock data.
  - c. System Statistics: including source availability, hours each source has been connected to the load, the number of times transferred, transfer times, and the total number of times each source has failed.
  - d. All event data in chronological order.
  - e. All active alerts in chronological order with alert type, fault codes, fault description, and time stamp.
  - f. Transfer Switch controller information, software version data, and serial/model numbers.
- 9. Contacts:
  - a. Digital Input/Output Contacts: Minimum 4 digital inputs and 4 solid state digital output relays with assignable functions.
  - b. Auxiliary Contacts: Isolated and driven by transfer switch mechanism, indicating switch position. Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 250-V AC.
  - c. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 5 A at 30-V DC minimum.
  - d. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
  - e. Signal-Before-Transfer and Post Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval adjustable from 0 to 600 seconds, and coordinated with any elevator equipment provided for the project.
  - f. Load Shed Circuit: Capable of moving switch to a neutral position when a signal is initiated from an external device, bypassing all time delays.
- 10. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle using preset schedules. Running periods shall be adjustable from 10 to 30 minutes. Factory

settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

- a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
  - b. Push-button programming control with digital display of settings.
  - c. Integral battery operation of time switch when normal control power is unavailable.
11. Security: Multi-level password security designed to restrict user access. Provide the following minimum access levels:
- a. User Level: Modifiable password that prevents unauthorized users from accessing setup screen and initiating tests using the test button on operator panel.
  - b. Advanced: allows users access to advanced parameters.
  - c. Service: allows users (authorized services technicians only) access to advanced and service screens.

## 2.3 BYPASS/ISOLATION SWITCH

- A. Source Limitations: Same manufacturer as transfer switch in which installed.
- B. Enclosed in the same cabinet as the automatic transfer switch, and UL-listed as an assembled product.
- C. Description: Two-way, **automatically and manually** operated, arranged to select and connect either source of power directly to load, bypassing and isolating transfer switch from load and from both power sources for testing and maintenance, without interruption of the power supply to the load. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
  1. Capable of operation using a keyed selector switch and a permanent external operating handle without the use of tools or opening the enclosure door.
  2. ~~With the ATS isolated or removed, the Bypass Switch shall be capable of automatically initiating and completing a transfer.~~
  3. Provide steel barriers for electrical and mechanical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
  4. Draw out Arrangement for Transfer Switch: Provide racking mechanism capable of moving transfer switch into three positions. The mechanism shall be interlocked so the transfer switch must be bypassed or open, before the mechanism will permit isolation of the transfer switch.
    - a. Connected: ATS fully racked-in and connected to main power bus and control power.
    - b. Test: ATS isolated from main power bus but remains connected to control power, capable of being electrically operated for test and exercise purposes with the enclosure door closed and without power disruption to the load.
    - c. Disconnected: ATS fully racked out and disconnected from the main power bus and control power, allows removal from the enclosure for inspection and and maintenance.
  5. Include electrical and mechanical interlocks to prevent unintentional paralleling of the power sources. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.

6. Dead Source Bypass: Utilize automatic means to prevent manual bypass to a dead source.
  7. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
  8. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
  9. **Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.**
  10. **Automatic and Nonautomatic Control Automatic transfer-switch controller shall also control the bypass/isolation switch.**
  11. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
- D. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

## 2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1. Calibrate all sensors.
- B. Prepare test and inspection reports.
1. For each of the tests required by UL 1008, performed on representative devices, for emergency and legally required systems. Include results of test for the following conditions:
    - a. Overvoltage.
    - b. Undervoltage.
    - c. Loss of supply voltage.
    - d. Reduction of supply voltage.
    - e. Alternative supply voltage or frequency is at minimum acceptable values.
    - f. Temperature rise.
    - g. Dielectric voltage-withstand; before and after short-circuit test.
    - h. Overload.
    - i. Contact opening.
    - j. Endurance.
    - k. Short circuit.
    - l. Short-time current capability.
    - m. Receptacle withstand capability.
    - n. Insulating base and supports damage.
- C. Product will be considered defective if it does not pass factory tests and inspections.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with manufacturers' written installation, application, and alignment instructions and with NFPA 70 and NFPA 110.
- B. Install floor mounted transfer switches on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 and **Section 260500, "Common Work Results for Electrical Systems."**
  - 1. Install conduits entering underneath the Transfer Switch, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
  - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Install anchor bolts to elevations required for proper attachment to Transfer Switch.
- C. Install wall mounted transfer switches plumb and rigid without distortion of enclosure.
  - 1. Provide steel slotted support structures where required for freestanding equipment or where building mounting surface is unsuitable.
  - 2. Where mounted in groups, align top of trim or tub for all panels in an area.

### 3.2 CONNECTIONS

- A. Coordinate with all trades for transfer switch interface with other building systems.
- B. Provide all interconnection wiring and raceway between system components and equipment. Install and connect wiring according to **Section 260519 "Low-Voltage Electrical Power Conductors and Cables."**
  - 1. Provide Class D extra flexible stranded conductors for all connections to genset.
  - 2. Control conductors installed between the transfer equipment, emergency generator, and docking station shall be kept entirely independent of all other wiring in accordance with NEC.
  - 3. Install wiring in raceways except within electrical enclosures. Size raceways to accommodate manufacturer's wiring requirements. Comply with **Section 260526 "Raceways and Boxes for Electrical Systems"**.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve

that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

- D. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary, to accommodate required wiring.

### 3.3 IDENTIFICATION

- A. Comply with requirements in **Section 260553 "Identification for Electrical Systems."**
  - 1. For equipment with temporary connections to a portable generator, provide warning sign near the connections that displays one of the following warnings, matching the permanent generator configuration:
    - a. **FOR CONNECTION OF A SEPARATELY DERIVED (BONDED NEUTRAL) SYSTEM ONLY**
    - b. **FOR CONNECTION OF A NONSEPARATELY DERIVED (FLOATING NEUTRAL) SYSTEM ONLY**

### 3.4 ADJUSTING

- A. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

### 3.5 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative to inspect and adjust components, assemblies, and equipment installations, including connections, and to assist in start-up and testing.
- B. The factory-authorized service representative shall perform a site evaluation prior to test and inspections to verify the equipment is installed in accordance with the manufacturer's instructions. Equipment shall be initially started and operated by the authorized service representative.
- C. Provide 7-day advance notice of any testing to allow The Engineer and Owner's Representative the option to witness the tests.
- D. Pre-Operational Tests and Inspections
  - 1. Visual and Mechanical Inspection:
    - a. Examine equipment nameplate data and confirm proper identification.
    - b. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
    - c. Inspect anchorage, alignment, and grounding.
    - d. Verify that the unit is clean.
    - e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

- f. Verify that warning labels and signs are attached and visible.
    - g. Verify tightness of all control connections.
    - h. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
    - i. Perform manual transfer operation.
    - j. Verify positive mechanical interlocking between normal and alternate sources.
  - 2. Electrical and Mechanical Tests:
    - a. Verify settings and operation of control devices.
    - b. Calibrate and set all relays and timers.
    - c. Verify phase rotation, phasing, and synchronized operation.
- E. Operational Tests: After electrical circuitry has been energized, test for compliance with performance requirements.
  - 1. Perform manual transfer tests.
  - 2. Perform automatic transfer tests:
    - a. Simulate loss of normal power.
    - b. Return to normal power.
    - c. Simulate loss of emergency power.
    - d. Simulate all forms of single-phase conditions.
  - 3. Verify correct operation and timing of the following functions:
    - a. Normal source voltage-sensing and frequency-sensing relays.
    - b. Engine start sequence.
    - c. Time delay upon transfer.
    - d. Alternate source voltage-sensing and frequency-sensing relays.
    - e. Automatic transfer operation.
    - f. Interlocks and limit switch function.
    - g. Time delay and retransfer upon normal power restoration.
    - h. Engine cool down and shutdown feature.
  - 4. Verify voltage and frequency pickup and dropout by data readout or inspection of control settings.
  - 5. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- F. Functional Acceptance Testing:
  - 1. Test the complete automatic transfer switch system and generator control system concurrently to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
- G. Transfer switches will be considered defective if they do not pass tests and inspections.
- H. Remove and replace malfunctioning units and retest as specified above.
- I. Prepare test and inspection reports.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
- B. Coordinate training with training for generator equipment.

END OF SECTION 263600



## SECTION 264100 - FACILITY LIGHTNING PROTECTION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Section includes requirements for providing a complete UL master labeled traditional lightning protection system for ordinary structures.
- B. Related Requirements:
  - 1. Refer to Section 260526, "Grounding and Bonding for Electrical Systems" for additional requirements related to grounding electrodes and connections.
  - 2. Refer to Section 264300, "Surge Protection Devices" for additional requirements related to surge suppression.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. LPI: Lightning Protection Institute
  - 2. LPS: Lightning Protection System
- B. Definitions
  - 1. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.
  - 2. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. National Fire Protection Association (NFPA)
    - a. NFPA 780, Standard for the Installation of Lightning Protection Systems
  - 2. Underwriters' Laboratories (UL)
    - a. UL 96, Standard for Lightning Protection Components

1.4 COORDINATION

- A. Coordinate system scope and layout requirements, attachment methods, and envelope penetrations with architectural roof plans, elevations, and sections.

1.5 PREINSTALLATION MEETINGS

- A. Schedule preconstruction conference with Architect, Owner, and all affected trades. Agenda topics should include, but are not limited to, the following:
  - 1. System Installation Schedule.
  - 2. Planned down conductor routing.
  - 3. Planned building enclosure penetrations.
  - 4. Building material compatibility.
  - 5. Cutting and patching requirements.
  - 6. Surge protection requirements.

1.6 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional responsible for their preparation.
  - 1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
  - 2. Include raceway locations needed for the installation of conductors.
  - 3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
  - 4. Include roof attachment and penetration details, coordinated with roof installation warranty.
  - 5. Calculations required by NFPA 780 for bonding of metal bodies.
- C. Delegated Design: For system layout, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional responsible for their preparation.
- D. Qualification Data: For Installer.
- E. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
- F. Sample Warranty.
- G. Closeout Submittals
  - 1. Operation and Maintenance Data: For lightning protection system to include in maintenance manuals.

2. In addition to items specified in Division 01 and Section 260010 “General Requirements for Electrical Systems” include the following:
  - a. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.
3. As-Built Data: Dimensioned site plan showing dimensioned route of the grounding electrodes.

H. Completion Certificate:

1. UL Master Label Certificate suitable for fastening to building for display.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Regularly engaged in manufacturer of lightning protection equipment, of types, sizes and ratings required, whose products have been satisfactorily used in similar service for not less than 5 years. The firm shall be a member of and certified by the Lightning Protection Institute.
- B. Installer Qualifications: A firm with at least 3 years of successful installation experience on projects with lightning protection work similar to that required for project
  1. The System Design shall be completed and the shop drawing stamped by an LPI Certified Master Installer – Designer of Lightning Protection Systems.
  2. The installing contractor shall be listed with the Lightning Protection Institute, and Underwriters’ Laboratories, Inc.
  3. The installation contractor shall have personnel on staff Certified by the LPI as a Master Installer – Designer of lightning protection systems.
  4. LPI qualified staff, Journeyman or higher, shall provide on-site supervision of the installation.

1.8 WARRANTY

- A. Furnish a 10-year adhesion warranty for all adhesives.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products from one of the following:
  1. East Coast Lightning Protection
  2. Harger
  3. nVent Erico
  4. Thompson Lightning Protection
  5. VFC/Lyncole
- B. Source Limitations: Obtain components through one source from a single manufacturer.

## 2.2 PERFORMANCE REQUIREMENTS

- A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I materials on structures not exceeding 75ft and Class II materials on structures or portions of structures exceeding 75ft.
- B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency suitable to the Authority Having Jurisdiction as complying with UL 96, and marked for intended location and application.
- C. Surge Suppression products for the electrical service entrance and communication services shall comply with NFPA 780 and UL 1449

## 2.3 MATERIALS

- A. Comply with minimum Class I and Class II material requirements as listed in NFPA 780.
- B. Air Terminals:
  - 1. Aluminum unless otherwise required due to adjacent materials or existing conditions.
  - 2. Safety tip.
  - 3. Threaded base support: Adhesive type for membrane roof, non-penetrating clamp for standing seam metal roof.
- C. Main and Secondary Conductors:
  - 1. Aluminum unless otherwise required due to adjacent materials or existing conditions.
  - 2. Smooth weave cable for Class I materials and Concentric or Ropelay for Class II materials
  - 3. Cable Fastener: Adhesive type for membrane roof, non-penetrating clamp for standing seam metal roof.
- D. Underground Conductors: Tinned copper.
- E. Ground Rods:
  - 1. Material: Copper-clad steel.
  - 2. Diameter: 3/4 inch.
  - 3. Rods: not less than 120 inches long.
- F. Conductor Splices and Connectors for aboveground applications:
  - 1. Suitable configuration and class type for the intended application and of the same material as the conductors or of electrolytically compatible materials
- G. Adhesives: High performance, solvent free, UV resistant, for durable bond with substrate. All adhesives must be compatible with the roofing material and approved by the roofing system manufacturer.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install lightning protection components and systems according to NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections without excessive splices. Maintain a horizontal or downward route along the entire path to ground. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.
- C. Rigidly fasten exposed conductors at intervals not exceeding 3 feet.
- D. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed systems in NFPA 780.
  - 1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid bars and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
  - 2. Install conduit where necessary to comply with conductor concealment requirements.
  - 3. Structural elements and design features shall be used whenever possible to minimize the visual impact of exposed conductors.
  - 4. Coordinate sequence of installation with other trades to avoid coring, cutting, and patching.
  - 5. Do not install conductors in gutters, downspouts, or on surfaces where water is retained.
- E. Where conductors are exposed to potential damage or environmental hazards at grade level, provide guards to protect the conductors to a point 10 feet above grade. Bond down conductors to guards or conduit at both ends.
- F. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- G. Provide Ground Ring Electrode for structures exceeding 60 feet. The conductor shall not be less than the main-size lightning conductor.
- H. Where local conditions such as soil material, earth resistivity, or limited project boundary require the use of other grounding electrode configurations, refer to grounding electrode requirements in Section 260526, "Grounding and Bonding for Electrical Systems".
- I. Provide bonding between the LPS grounding electrode system and the Building grounding electrode system in accordance with NEC and NFPA 780 requirements.
- J. Install surge suppression at all power service entrances and at all entrances of conductive communications systems.
- K. Provide cutting and patch as necessary for installation of work in existing structures. Refer to Section 260500, "Common Work Results for Electrical Systems".

### 3.2 CONNECTIONS

- A. All connections to down conductors and connections in earth or concrete: Exothermic weld.
- B. Aboveground concealed connections: Exothermic welds or high-compression fittings listed for the purpose.
- C. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors, exothermic weld, high compression, or crimp type.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
- E. Follow manufacturer's temperature and substrate requirements for installation of adhesives.

### 3.3 CORROSION PROTECTION

- A. Coordinate lightning protection materials with building materials to assure compatibility.
- B. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- C. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.
- D. Provide bimetallic connectors and fittings for splicing or bonding dissimilar metals.
- E. Do not install aluminum materials in the following locations:
  - 1. Embedded in or in direct contact with concrete, masonry, limestone, plaster, or mortar.
  - 2. On copper surfaces or in locations exposed to direct water run-off from copper surfaces.
  - 3. On a building surface coated with alkaline based paint.
  - 4. In direct contact with earth or within 18-inches of the point where a conductor comes into contact with the earth.
- F. Do not install copper materials in the following locations:
  - 1. On aluminum surfaces or on exterior sheet metal surfaces.

3.4 FIELD QUALITY CONTROL

- A. Testing: Upon completion of installation of lightning protection system, test resistance-to-ground with resistance tester. Where tests show resistance-to-ground is over 25 ohms, take appropriate action to reduce resistance to 25 ohms, or less, by driving additional ground rods.
- B. Engage a third-party inspector to perform inspections required to obtain a UL Master Label for the system.
- C. Prepare detailed test and inspection reports with corresponding test results and photos.

END OF SECTION 264100

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## SECTION 264300 - SURGE PROTECTION DEVICES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: The Contractor shall provide the necessary labor, materials, wiring and services necessary to provide the complete electrical surge protection systems as specified herein. This work shall include, but is not necessarily limited to provision of Surge Suppression Units at certain points in the power distribution network and proper installation in accordance with manufacturer's instructions.
- B. Section includes:
  - 1. Requirements for both field-mounted SPDs (externally mounted), and integrated SPDs (installed from the factory) for low voltage power distribution and control equipment.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. MCOV: Maximum continuous operating voltage.
  - 2. OCPD: Overcurrent protective device.
  - 3. SCCR: Short-circuit current rating.
  - 4. SPD: Surge protective device.
  - 5. VPR: Voltage protection rating.
- B. Definitions
  - 1. Inominal: Nominal discharge current.
  - 2. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
  - 3. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
  - 4. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.
  - 5. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.
  - 6. Type 3 SPDs: Point of utilization SPDs.

- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
    - a. ANSI/IEEE C62.41.1, "Guide on the Surges Environment in Low Voltage (1000 V and Less) AC Power Circuits."
    - b. ANSI/IEEE C62.41.2, "Recommended Practice on Characterization of Surges in Low Voltage (1000 V and Less) AC Power Circuits."
    - c. ANSI/IEEE Standard C62.45, "Guide on Surge Testing for Equipment Connected to Low-Voltage Ac Power Circuits"
  2. Underwriters Laboratories, Inc. (UL)
    - a. UL 1283, "Standard for Safety for Electromagnetic Interference Filters."
    - b. UL 1449, "Standard for Surge Protective Devices."

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product.
1. Indicate all capacity ratings, clamp times, maximum capacities, physical characteristics and listing agency approvals.
  2. Copy of UL certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
  3. Wiring diagram showing all manufacturer installed wiring including wire size, type, routing, and exact length of conductors.
- B. Product Schedule: Indicate where each type of SPD is installed.
- C. Closeout Submittal
1. Operation and Maintenance Data: For surge protection devices and components to include in emergency, operation, and maintenance manuals.

#### 1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within a period of ten years from the date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB/General Electric Company.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. Siemens.
4. Square D; a brand of Schneider Electric.

- B. Source Limitations: SPDs installed internal to the distribution system shall be of the same manufacturer as the equipment. The equipment shall be fully tested and certified in accordance with UL standards.

## 2.2 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- B. SPDs: Comply with UL 1449
1. Provide Type 1 SPDs installed on the line side of the service entrance OCPD and Type 2 SPDs installed on the load side of the service entrance OCPD.
- C. Electrical Noise Filter: Comply with UL 1283 for Type 2 SPDs.
1. Each Type 2 unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz
- D. Unit Operating Voltage: Refer to drawings.
- E. MCOV of the SPD shall not be less than 115% of the nominal system voltage.
- F. The suppression system shall incorporate thermally protected MOVs as the core surge suppression component for all distribution levels. Each MOV shall be individually fuse-protected to avoid cascading faults. The thermal protection assembly shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.
- G. SPDs shall be provided with the following features and accessories:
1. Integral disconnect switch for externally mounted SPDs. SPDs integrated into factory supplied equipment shall have an input disconnect switch or circuit breaker unless indicated on the equipment drawings/data sheets.
  2. Internal fusing that disconnects the SPD before damaging internal suppressor components.
  3. Indicator light display (Red and Green) for power and protection status with push-to-test capabilities.
  4. Audible alarm with silencing switch. Alarm shall activate when any one of the surge current modules has faulted or reached an end-of-life condition.
  5. Form-C contacts, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
  6. Surge counter with LCD display, reset switch, non-volatile memory, and battery backup to retain memory upon loss of AC power.

- H. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.
- I. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than the following values. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
  - 1. Category C, Service Entrance larger than 1200A: 400 kA/phase.
  - 2. Category C, Service Entrance 1200A and below: 240 kA/phase.
  - 3. Category B, Distribution larger than 1200A: 300 kA/phase.
  - 4. Category B, Distribution 1200A and below: 160 kA/phase.
  - 5. Category B, Branch: 120kA/phase.
- J. Protection modes and UL 1449 VPR for grounded wye circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
  - 2. Line to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
  - 3. Neutral to Ground: 1200 V for 480Y/277V and 700 V for 208Y/120 V.
  - 4. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.
- K. SCCR: The short circuit current rating of the SPD shall be a minimum of 200kA and equal to or greater than the available short circuit current at the point on the system where installed.
- L. Minimum Inominal Rating: 20 kA

## 2.3 SURGE SUPPRESSORS FOR OTHER SYSTEMS

- A. Refer to specific specification sections for additional information on surge suppressors related to other building systems.

## 2.4 ENCLOSURES

- A. Enclosure shall meet or exceed the ratings for the environment to be installed as indicated on drawings.
  - 1. Indoor locations: NEMA 250, Type 1.
  - 2. Outdoor or wet locations: NEMA 250, Type 3R.
  - 3. Corrosive Environments: NEMA 250, Type 4X.

## 2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Provide sizes to match SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Factory install integral SPDs as part of the distribution equipment and connect through a disconnect.
  - 1. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
- C. Provide a OCPD as required to comply with the UL listing of the SPD and selected to comply with power system study.
- D. Install SPDs with properly rated conductors between suppressor and points of attachment as short and straight as possible with no sharp bends, and adjust circuit-breaker positions to achieve shortest and straightest leads.
- E. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
- F. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- G. Twist input conductors together to reduce the input inductance.
- H. Use crimped connectors and splices only. Wire nuts are not acceptable.

### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
  - 2. Inspect anchorage, alignment, grounding, and clearances.
  - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

- C. Energize SPDs after power system has been energized, stabilized, and tested.

#### 3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264300

## SECTION 265000 - LIGHTING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. This section is intended to specify in conjunction with the Light Fixture Schedule, the luminaires, supports, accessories, specialties and related items necessary to complete the work as shown on the drawings.
- B. Section Includes:
  - 1. Interior light fixture
  - 2. Exterior light fixtures including building mounted
  - 3. Exit signs
  - 4. Emergency lighting units
  - 5. LEDs and drivers
  - 6. Light fixture supports and accessories

#### 1.3 COORDINATION

- A. This work consists of providing all labor, materials, accessories, mounting hardware and equipment necessary for an operationally and aesthetically complete installation of all luminaires, including power wiring, control wiring and accessories, in accordance with the contract documents.
- B. Contractor shall provide all luminaires, as herein specified, complete with lamps, drivers, power supplies, ballasts and accessories for safe and effective operation. All fixtures shall be installed and left in an operable condition with no broken, damaged or soiled parts.
- C. Contractor shall coordinate all infrastructure requirements with all approved lighting equipment prior to infrastructure installation, including, but not limited to appropriately sized, positioned and located junction boxes, structural supports, feeds, power and control conduits, and remote code-compliant power-supply enclosures.
- D. All available finishes and colors, for each luminaire, shall be submitted to the Architect for selection during shop drawing review. Premium finishes, where indicated, shall be provided at no additional cost premium.
- E. Specifications and drawings are intended to convey all salient features, functions and characteristics of the luminaires only, and do not undertake to illustrate or set forth every item

or detail necessary for the work. Minor details, not usually indicated on the drawings nor specified, but that are necessary for proper execution and completion of the luminaries, shall be included, the same as if they were herein specified or indicated on the drawings.

- F. The Owner, Architect and Engineer shall not be held responsible for the omission or absence of any detail, construction feature, etc. which may be required in the production of the light fixtures. The responsibility of accurately fabricating the light fixtures to the fulfillment of the specification rests with the Contractor.
- G. Refer to architectural details, as applicable, for recessed soffit fixtures or wherever fixture installations depend upon work of other trades. Coordinate all installations with other trades. Verify dimensions of spaces for fixtures, and if necessary, adjust lengths to assure proper fit and illumination of diffuser and/or area below.
- H. In accordance with the above and the criteria established herein, the Contractor is responsible for assuring the final design, fabrication and installation which fulfills the requirements of the Contract Documents.

#### 1.4 REFERENCES

##### A. Abbreviations and Acronyms

- 1. CCT: Correlated color temperature
- 2. CRI: Color-rendering index
- 3. CU: Coefficient of utilization
- 4. IECC: International Energy Conservation Code
- 5. LER: Luminaire efficacy rating, which is calculated according to NEMA LE 5.
- 6. NRTL: Nationally Recognized Testing Laboratory
- 7. SPD: Surge Protective Device
- 8. RCR: Room cavity ratio.
- 9. UL: Underwriters Laboratory

##### B. Definitions

- 1. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in the IESNA Lighting Library.
- 2. Light Fixture (Luminaire): Complete lighting unit consisting of a lamp(s) and driver(s)/ballast(s) (when applicable) together with the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamps to the power supply.
- 3. Lumen: Delivered output of luminaire.
- 4. Total harmonic distortion (THD): The root mean square (RMS) of all the harmonic components divided by the total fundamental current.
- 5. Pole: Luminaire support structure, including tower used for large area illumination.
- 6. Standard: Same definition as "Pole" above.

##### C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version (including amendments, addenda, revisions, supplements, and errata) as of the date of the Contract Documents, unless otherwise specified.

- 1. Illuminating Engineering Society of North America (IESNA)



- a. IES LS-1-20, Lighting Science: Nomenclature and Definitions for Illuminating Engineering
2. National Electrical Manufacturer's Association (NEMA)
  - a. NEMA SSL 1, Electronic Drivers for LED Devices, Arrays or Systems
  - b. NEMA SSL 3, High-Power White LED Binning for General Illumination

## 1.5 SUBMITTALS

- A. Product Data: For each type and model of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
  1. Physical description of lighting fixture including dimensions.
  2. Emergency lighting units including battery and charger.
  3. All available finishes and colors for each luminaire type shall be submitted to the Architect for selection during review.
  4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for light fixtures.
  5. Dimensions, effective projected area (EPA), accessories, installation details and construction details.
  6. Distribution data according to IESNA classification type as defined in IESNA handbook.
  7. US DOE LED Lighting Facts Label and IESNA L70 rated life.
  8. Amount of shielding on luminaires.
  9. Control type: 0-10V, DMX, bi-level, etc.
- B. Shop Drawings: Including plans, elevations, sections, details, and attachment to other work.
  1. Include detailed equipment assemblies and indicate electrical ratings, dimensions, emergency section, control type, wiring, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  2. Wiring Diagrams: For power, signal and control wiring.
  3. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
- C. Sample Warranty
- D. Closeout Submittals
  1. Maintenance Contract
  2. Operation and Maintenance Data
  3. Warranty Documentation
  4. Record Documentation
  5. Sustainable Design Closeout Documentation
  6. Software

## 1.6 MAINTENANCE MATERIAL

- A. Furnish the following extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing content:
  1. Single Sided Exit Sign: One for every 15 of each type. Furnish at least two of each type.
  2. Double Sided Exit Sign: One for every 15 of each type. Furnish at least one of each type.

3. LED Drivers: One for every 50 of each type and rating installed. Furnish at least 5 of each type.
4. LED Lamps/Boards: One for every 100 of each type and rating installed. Furnish at least two of each type.
5. Emergency battery pack: One for every 50 units. Furnish at least one of each type.

#### 1.7 QUALITY ASSURANCE

- A. In each of the publications referred to herein, consider the advisory provisions to be mandatory.
- B. Manufacturer Qualifications: Equipment shall be supported by service organizations which are reasonably convenient (less than 100 miles from project site) to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.
- C. Where groups of luminaire types exhibit the same list of acceptable Manufacturers, such as downlights, accents, and wall washers, the intent is to have a final installation with the same Manufacturer's equipment across the groupings as specified for consistency of optics, aesthetics, and similarity of maintenance procedures. Mixing/matching across groups is unacceptable. This also applies to multi-phased projects with single or multiple, but related luminaire types exhibiting the same list of acceptable Manufacturers, except where products have subsequently been discontinued or significantly redesigned in size, appearance, lamping, or gear. Lamps shall be from a single manufacturer and batch.

#### 1.8 DELIVERY, STORAGE AND HANDLING:

- A. The Contractor shall provide, receive, unload, uncrate, store, protect and install lamps, luminaires and auxiliary equipment, as specified herein, in accordance with respective manufacturers' project conditions of temperature and humidity and with appropriate protection against dust and dirt. Lamps for miscellaneous equipment shall be provided and installed by the Contractor according to equipment manufacturers' guidelines.
- B. All products shall be stored in manufacturer's unopened packaging until ready for installation.

#### 1.9 COORDINATION

- A. Coordinate layout and installation of exterior lighting fixtures with all other construction including all underground utilities and geothermal well fields.
- B. Coordinate layout and installation of lighting fixtures with all other construction that penetrates ceilings or is supported by them, including HVAC equipment, plumbing, fire-suppression system and partition assemblies.
- C. Contractor shall coordinate all infrastructure requirements with all approved lighting equipment prior to infrastructure installation, including, but not limited to appropriately sized, positioned and located junction boxes, structural supports, feeds, power and control conduits, and remote code-compliant power-supply enclosures.

- D. Prior to procurement of light fixtures:
  - 1. Confirm application and required voltage.
  - 2. Confirm the proper and complete catalog number with distributor and agent.
  - 3. Ensure wiring, driver, etc meets the specifications and proper requirements.
  - 4. Provide additional parts and pieces required to complete the installation in the location and manner intended by the design.
- E. Light fixture locations in mechanical and electrical equipment rooms/areas are approximate. Locate light fixtures to avoid equipment, ductwork, and piping. Locate around and between equipment to maximize the available light. Coordinate mounting heights and locations of light fixtures to clear equipment. Request a meeting with the Engineer if uncertain about an installation.
- F. Coordinate between the electrical and ceiling trades to ascertain that approved luminaires are furnished in the proper sizes, with the proper flange details, and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.

#### 1.10 WARRANTIES

- A. Manufacturer Warranty: All luminaries, finishes, poles, batteries, supports, accessories and all of its component parts, workmanship, and controls shall have an unconditional five (5) year on-site replacement warranty. Warranty shall include all light fixtures, lamps, drivers, poles, finishes and all components to be free from defects in materials and workmanship for a period of five (5) years from date of Owner's acceptance. On-site replacement includes transportation, removal, and installation of new products. Replacement of luminaries, faulty materials and the cost of labor to make the replacement shall be the responsibility of the Contractor.
  - 1. Luminaires: Five (5) years from date of substantial completion.
  - 2. LED drivers: Ten (10) years from the date of substantial completion. The warranty shall state the malfunctioning LED driver shall be exchanged by the manufacturer and promptly installed by the Contractor. The replacement LED driver shall be identical to, or an improvement upon, the original design of the malfunctioning LED driver.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

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

#### 2.2 MANUFACTURERS

- A. Subject to compliance with requirements, provide one of the products indicated on Light Fixture Schedule. Refer to Light Fixture Schedule for manufacturers and model numbers. Basis of

Design for each light fixture type shall be the first fixture manufacturer and model number for each type listed.

- B. Manufacturer's catalog numbers together with the descriptions on the drawings and these specifications are indicative of required design, appearance, quality and performance. Report any discrepancies between any of these to the Engineer for resolution prior to bid. In absence of such notice to the Engineer, provide the greater requirement as directed by the Engineer, without additional cost.

## 2.3 EQUAL MANUFACTURERS

- A. Manufacturers listed as "Equal" to the Basis of Design on the light fixture schedule shall submit product cutsheets to the Engineer prior to bid for final written approval. This written approval will only be issued in addendum form. "Equal" fixtures shall be of equal or better quality and performance to the fixture(s) listed with manufacturer's model numbers. Burden of proof shall be on the Contractor, Vendor and manufacturer.
- B. Upon request by Engineer, the Contractor shall submit manufacturer's computerized horizontal illumination levels using AGI32 software in footcandles at workplane (30" above finished floor), taken every 3 feet in every interior room and area. Include average maintained footcandle levels and maximum and minimum ratio.
- C. Upon request by Engineer, the Contractor shall submit manufacturer's computerized horizontal illumination levels using AGI32 software in footcandles, taken every ten (10) feet at grade for the entire exterior site. Include average maintained footcandle levels and maximum and minimum ratio.
- D. Refer to specification Section 260010 "General Requirements for Electrical Systems" for additional requirements.

## 2.4 GENERAL REQUIREMENTS FOR LUMINAIRES AND COMPONENTS

- A. Complete luminaires shall be in accordance with NFPA 70, NEMA, and UL 1598 listed and labeled.
- B. Ballasts, drivers, or transformers, unless otherwise specified, shall be field replaceable and shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.
- C. Luminaires shall be entirely factory wired by the luminaire manufacturer in accordance with code and UL requirements and shall be furnished fully compatible with the project electrical wiring and controls system for smooth, continuous, dimming or on/off flicker-free operation.
- D. Exterior building mounted light fixtures shall be UL classified for damp or wet locations as applicable and shall be complete with gaskets, cast aluminum outlet box and grounding. Luminaires shall be suitably gasketed and vented according to manufacturer's instructions. All dissimilar metal materials shall be separated by non-conductive materials to prevent galvanic action.

- E. All luminaires supplied for recessing in suspended ceilings shall be supplied with pre-wired junction boxes, unless otherwise specified.
- F. Metal parts: Free of burrs, sharp corners and sharp edges.
- G. Doors, frames and other internal access: Smooth operating, free of light leakage under operating conditions. Designed to prevent doors, frames, lenses, diffusers and other components from falling accidentally during maintenance and when secured during operating position.
- H. Mounting Frames and Rings: If ceiling system and luminaire type requires, each recessed and semi-recessed luminaire shall be furnished with a mounting frame or ring compatible with the ceiling in which they are to be installed as coordinated by Contractor. The frames and rings shall be one piece and of sufficient size and strength to sustain the weight of the luminaire and maintain plumb. Luminaires shall be braced such that the force required to close and/or latch lens or door frame does not lift or shift luminaire.
- I. Pendant Supports: Contractor shall be responsible for coordination with Manufacturer, Architect, Structural Engineer and related trades to ensure that proper and adequate structural reinforcement is provided within ceilings to support pendant mounted lighting equipment for a secure, neat, square, plumb appearance. Pendants shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.
- J. Wall Bracket (Sconce) Supports: Contractor shall be responsible for coordination with Manufacturer, Architect, Structural Engineer and related trades to ensure that proper and adequate structural reinforcement is provided within walls to support wall mounted lighting equipment for a secure, neat, square, plumb appearance. Wall brackets shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.
- K. All lenses or other light diffusing elements shall be removable for access to lamp and electrical and electronic components and luminaire cleaning, however, they must otherwise be positively and securely held in-place, unless otherwise specified.
- L. All lens door or holder trim flanges shall fit plumb and flush with the ceiling or wall surface. There shall be no light leaks around the interface between lens door or holder trim flanges and the ceiling or wall.
- M. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility.
- N. Recessed luminaires mounted in an insulated ceiling shall be listed for use in insulated ceilings, IC-rated, or provisions made to maintain code-compliant 3" air-space around luminaires in accordance with Manufacturers' instructions.
- O. Mechanical Safety: Unless otherwise specified, luminaire closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

- P. Unless otherwise specified, luminaires with louvers or light transmitting panels shall have hinges, latches and safety catches to facilitate safe, convenient cleaning and re-lamping. Vapor tight luminaires shall have stainless steel pressure clamping devices.
- Q. Yokes, brackets and supplementary supporting members necessary for mounting lighting equipment shall be furnished and installed by the Contractor and approved by the Architect. All materials, accessories, and any other equipment necessary for the complete and proper installation of luminaires, lamps, ballasts/neon transformers included in the contract shall be furnished and installed by the Contractor. All yokes, brackets and supplementary supports shall provide a neat, square, plumb and level appearance, and shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with all lamps, globes, lenses, lens frames or doors etc. in place.
- R. All connections shall be fixed rigid by screws, rivets and/or soldering. Screws and rivets shall not be visible except as necessary for maintenance and/or aesthetic appearance. All connections shall provide a neat, square, plumb and level appearance, and shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.
- S. All housings shall be free from tool marks and dents and shall have accurate angles bent as sharp as compatible with the gauges of the required metal and the luminaire styling. All intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly.
- T. For steel and aluminum luminaires, all screws, bolts, nuts and other fastening and latching hardware shall be a cadmium or equivalent plated. For stainless steel luminaires, all hardware shall be stainless steel. For all bronze luminaires, all hardware shall be bronze.
- U. Extruded aluminum frames and trims shall be rigid and manufactured from quality aluminum without blemishes in the installed product. Miter cuts shall be accurate; joints shall be flush and without burrs and cut alignment maintained with the luminaire located in its final position.
- V. Castings shall exactly replicate the approved pattern(s) and shall be free of sand pits, blemishes, scales and rust and shall be smoothly finished, excepted as necessary for an authentic historic appearance and as agreed by Architect. Tolerances shall be provided for any shrinkage in order that the finished castings accurately fit their locations resulting in plumb and level fit and consistently tight-seamed fittings.
- W. Luminaires in Hazardous Areas: Luminaires shall be suitable for installation in flammable atmospheres (Class and Group) as defined in NFPA 70 and shall comply with UL 844.
- X. Each light fixture shall be packaged with complete instructions and illustrations on how to install.
- Y. Each light fixture box, container, etc shall be labeled at the factory with the type designation as indicated on the Light Fixture Schedule.
- Z. Provide factory cut custom stem lengths, as required.

- AA. Exit signs and fixtures that are hatched or where the fixture type contains the suffix "E" for emergency operation, the fixture shall have an integral 90-minute battery inverter if not powered from an emergency generator.
- BB. All battery powered fixtures shall have test switches factory installed integral to the reflector. Remote test switches will not be accepted.

## 2.5 LUMINAIRE REFLECTORS AND TRIMS

- A. Alzak cones, reflectors, baffles and louvers shall be warranted against discoloration.
- B. All trims, reflectors and canopies shall fit snugly and securely to the ceiling or wall so that no light leak occurs.
- C. Trims shall be self-flanged, unless otherwise specified.
- D. For trimless or flangeless luminaires, Contractor shall coordinate with other Trades to achieve a trimless/flangeless installation acceptable to the Architect. Where ceilings are drywall or plaster, this involves Level 5 finishes or as otherwise directed by the Architect. In drywall, plaster, wood, or stone ceilings, special luminaire collars and exacting coordination are required of Contractor.

## 2.6 LIGHT EMITTING DIODE (LED) ELECTRONIC DRIVERS

- A. The electronic drivers shall as a minimum meet the following characteristics:
  - 1. LED drivers shall comply with NEMA SSL 1, NFPA 70, and UL 8750 unless otherwise specified.
  - 2. Driver shall comply with UL 1310 Class 2 requirements for dry and damp locations, NFPA 70 unless specified otherwise. Drives shall be designed for the wattage of the LEDs used in the indicated application. Drivers shall be designed to operate on the voltage system to which they are connected.
  - 3. LED driver shall withstand up to a 1,000-volt surge without impairment of performance as defined by ANSI C62.41 Category A.
  - 4. LED driver shall tolerate  $\pm 10$  percent supply voltage fluctuation with no adverse effects to driver or LEDs.
  - 5. Drivers for luminaires controlled by dimming devices shall be as specified herein and equipped for dimming and conform to the recommendations of the manufacturer of the associated dimming devices to assure satisfactory operation of the lighting system. Contractor shall coordinate all wiring infrastructure to accommodate final-selected drivers and controls systems for smooth, continuous, and flicker-free operation.
  - 6. Flicker: The flicker shall be less than 5 percent at all frequencies below 1000 Hz and without visible flicker.
  - 7. Provide with short circuit, open circuit and overload protection.
  - 8. Drivers shall meet or exceed NEMA 410 driver inrush standard.
  - 9. Total Harmonic Distortion shall be less than 20 percent.
  - 10. Power Factor to be greater than 95%
  - 11. Drivers to be reduction of hazardous substances (ROHS) compliant

## 2.7 LIGHT EMITTING DIODE (LED)

- A. The light emitting diodes shall as a minimum meet the following characteristic:
  - 1. LED lamps shall comply with ANSI C78.1, IESNA LM-79 and IESNA LM-80.
  - 2. Light emitting diodes shall be tested under IES LM-80 standards.
  - 3. Color Rendering Index (CRI) shall be 84 (minimum).
  - 4. Rated lumen maintenance of 90% lumen output at 50,000 hours (minimum).
  - 5. Rated lumen maintenance of 70% lumen output at 100,000 hours (minimum).

## 2.8 SUSPENDED LUMINAIRES

- A. Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers shall allow fixtures to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Single-unit suspended fixtures shall have twin-stem hangers. Multiple-unit or continuous row fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 0.18 inch diameter.
- B. All suspended luminaires with a weight in excess of 50 pounds shall be fitted with safety cable of sufficient strength and length to meet all UL safety cable load-bearing requirements. Cable shall exhibit a finish (but not painted) compatible with that of the metal finish of the stem/chain/suspension-cable assembly or alternatively finished in black as approved by Architect. Shop drawings shall indicate luminaire weight. Contractor shall coordinate structural support/attachment requirements including independent structure for safety cable attachment with Vendor, Architect, and Structural Engineer and all respective trades. Safety cable shall exhibit sufficient length to wrap tightly and entirely around structural member at least twice before attachment subject to Vendor confirmation of UL requirements and pending Structural Engineer review. Contractor shall provide labor necessary for the stem/chain-assembly-wiring-threading and safety-cable-attachment as instructed by Vendor.

## 2.9 DOWNLIGHT FIXTURES AND COMPONENTS

- A. Downlights shall be listed for thru-branch circuit wiring, recessing in ceilings and damp locations.
- B. Where installed in plaster or drywall or other inaccessible ceiling types, they shall be UL listed for bottom access.
- C. Provide with tool-less hinged junction box access cover and thermal protection accessible from below through reflector opening.
- D. Provide telescoping channel bar hangers that adjust vertically and horizontally.



## 2.10 EXIT SIGNS

- A. General requirements: Comply with UL 924, NFPA 70, AND NFPA 101.
- B. All exit signs shall be LED type.
- C. Provide single or double face as scheduled, indicated on plans or as required by the local Authority Having Jurisdiction. Adjust installation position if required for clear visibility, in accordance with applicable codes.
- D. Provide directional arrows (chevrons) as indicated on floor plans and to suit the means of egress or as required by the local Authority Having Jurisdiction.
- E. Where emergency backup battery packs are provided with exit lights, they shall have capacities for continuous operation per applicable codes. All exit signs with battery backup shall be provided with self-diagnostics.
- F. Complete unit to be furnished in color/finish as selected by the Architect.

## 2.11 EMERGENCY DRIVER

- A. Description: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with driver. Complying with UL924.
  - 1. Provide a minimum of 90 minutes of battery back-up upon loss of power.
  - 2. Constant Power Output: minimum 10W, uon.
  - 3. Battery: High temperature Nickel Cadmium or Lithium Iron Phosphate, uon.
  - 4. Charger: Fully automatic, solid-state type with sealed transfer relay.
  - 5. Operation: Solid state switching circuit automatically turns light fixture on upon absence of power-supply circuit voltage and switches back to normal operation upon restoration of AC power.
  - 6. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
    - a. Push-Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - b. Indicator Light: LED indicates normal power on and charger operation.
  - 7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

## 2.12 LUMINAIRE SUPPORT HANGERS AND COMPONENTS

- A. Wires: ASTM A641/A641M, Class 3, soft temper, galvanized regular coating, 0.1055 inches in diameter (12 gage).
- B. Straps: Galvanized steel, one by 3/16 inch, conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.
- C. Rod Hangers: Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

## 2.13 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

- A. Provide poles designed for site specific wind loading (minimum of 120 miles per hour) determined in accordance with AASHTO LTS while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be anchor-base type designed for use with underground supply conductors. Poles shall have full base metal covers with matching finish to conceal the mounting hardware, pole-base welds and anchor bolts..
- B. Structural Characteristics: Comply with AASHTO LTS
  - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
  - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.3 to obtain the equivalent projected area to be used in pole selection strength analysis.
- C. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners, unless otherwise indicated.
- D. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
  - 1. Materials: Shall not cause galvanic action at contact points.
  - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
  - 3. Anchor-Bolt Template: Plywood or steel.
- E. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.
- F. Breakaway Supports: Provide frangible breakaway supports where noted on plans, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS.
- G. Brackets and Supports
  - 1. ANSI C136.3, ANSI C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 1-1/4 inch secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head. Detachable, cantilever, without underbrace.
- H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- I. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching

grounding and bonding conductors of type and size listed in that Section, and accessible through handhole. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire.

- J. Finish: Same as luminaire.

## 2.14 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
  - 1. Relay with locking-type receptacle shall comply with ANSI C136.10.
  - 2. Adjustable window slide for adjusting on-off set points.

## 2.15 FACTORY APPLIED FINISH

- A. Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 INSTALLATION

- A. Architect's reflected ceiling plan (RCP) indicates actual locations of all light fixtures, diffusers and system devices. Report to the Architect/Engineer any conflicts. Do not scale plans for exact location of lighting fixtures.
- B. Coordinate mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed.
- C. Install luminaires in accordance with luminaire manufacturer's written instructions, applicable requirements of NEC, NECA, and NEMA standards.

- D. Installed luminaires shall be provided with protective covering by Contractor until such time as the space(s) is cleaned and ready for occupancy.
- E. Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secured in accordance with manufacturers' directions and approved drawings.
- F. Lighting Fixture Supports:
  - 1. Comply with Section 260500, Common Work Results for Electrical Systems.
  - 2. Sized and rated for luminaire weight.
  - 3. Shall maintain the fixture positions after cleaning and re-lamping.
  - 4. Ensure that the luminaires are supported such that there is no resultant bowing or deflection of the ceiling or wall system.
  - 5. Capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- G. Recessed, semi-recessed and surface fixtures shall be independently supported from the buildings structure. Do not support any luminaire solely from ceiling grid or ceiling. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures.
- H. Ceiling Grid mounted light fixtures:
  - 1. Lighting fixtures installed in suspended ceilings shall also comply with the requirements of Division 09 Specification Sections for ceilings.
  - 2. Support fixtures with four (4) wires with one (1) at each corner.
  - 3. Hanger wires: Install within 15 degrees of plumb or additional support shall be provided. Wires shall be attached to fixture body and to the building structure (not to the supports of other work or equipment). Where building structure is located such that 15 degrees cannot be maintained, provide "strut" or similar supports secured to structure to meet this requirement.
  - 4. Support Clips: Provide four (4) clips per fixture minimum. Fasten to light fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application. Install clips per manufacturer's requirements. If screws are required, they shall be provided. Installation shall meet applicable seismic codes.
  - 5. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently and provide at least two 3/4-inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture.
  - 6. Downlights, exit signs and battery pack supported by or attached to ceiling grid or tile shall be provided with one hanger wire at each end. Provide a minimum of two, located at opposite corners.
  - 7. Round fixtures or fixtures smaller in size than the ceiling grid shall be independently supported from the building structure by a minimum of four wires per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels.
- I. Suspended fixtures:
  - 1. Hang plumb and shall be located with no obstructions within the 45 degree range in all directions. The stem, cable, canopy and fixture shall be capable of 45 degree swing.

2. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects.
  3. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel.
  4. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown.
  5. Whenever a luminaire or its hanger canopy is installed directly to a surface mounted junction box, a finishing ring painted to match the ceiling, shall be used to conceal the junction box.
- J. Wall mounted fixtures:
1. Do not attach light fixtures directly to gypsum board.
  2. Attach to structural members in walls or backing plate attached to wall structural members.
- K. Rigidly align continuous rows of light fixtures for true in-line appearance.
- L. Exit Signs and Emergency Lighting Units: Wire exit signs ahead of the switch to the un-switched branch circuit located in the same room or area. Connect to emergency system branch circuit where applicable.
- M. Where emergency battery packs are provided with fixtures (if any), they shall be connected to an un-switched power line and wired in accordance with applicable codes and the manufacturer's recommendations.
- N. Light fixture whips shall be independently supported from the building structure. Do not clip to lay-in ceiling support wires. Independent support wires shall be distinguishable by colors, tagging, or other effective means.
- O. Exterior Fixtures:
1. Exterior building mounted light fixtures shall not be installed until after the building exterior has been rinsed clean of any corrosive cleaning materials. Damaged fixtures shall be replaced by the Contractor at no cost.
  2. Provide exterior rated weather proof junction boxes for all fixtures and splices.
  3. Utilize weatherproof silicone filled wire nuts and seal all junction boxes and conduit with potting compound to create waterproof barriers. Inspect all splices and fixtures for continuity prior to potting.
  4. Lubricate all threaded parts with a high temperature waterproof anti-seize lubricant to prevent seizing and corrosion.
  5. All low-voltage wiring to be UV resistant, UL approved for use without conduit, stranded low-voltage wire for use in outdoor and underground applications, gauge as appropriate to avoid voltage drop.
  6. Provide surface mounted fixtures with conduit hub for end of fixture entrance.
- P. Transformers (applies to all transformers including (but not limited to) low voltage, neon, remote ballast, LED power supplies, exterior locations):

1. Electrical Contractor to locate all transformers (including low voltage, neon, remote ballasts, led power supplies, etc.) near fixtures in a well-ventilated and accessible location. Transformers must be installed (per codes) in accessible areas large enough to dissipate the heat of the transformer. Temperatures should not exceed 100°F (38°C) or that required by manufacturer if more stringent.
2. Electrical Contractor to determine wire size according to load and wire length to eliminate voltage drop. If voltage drop is a problem after installation, the Electrical Contractor is responsible for reinstallation (at no additional cost) of transformer and wire to solve problem.
3. Electrical Contractor to label front of transformer/driver. Example: "Large Display Case @ Entry to Main Dining Room."

- Q. Seal all knock-outs, conduit, and wire entrances for all luminaires in wet and damp locations to prevent water wicking.
- R. All reflecting surfaces, glass or plastic lenses, ballast housings, parabolic louvers, downlighting alzak cones and specular reflectors and other decorative elements shall be installed after completion of ceiling tile installation, plastering, painting and general cleanup.
- S. Handle all reflecting surfaces, glass or plastic lenses, ballast housings, parabolic louvers, downlighting alzak cones and specular reflectors and other decorative elements with care during installation or lamping to avoid fingerprints or dirt deposits.
- T. Luminaires installed and used for working light during construction shall be replaced prior to turnover to the Owner if more than 3 percent of their rated life has been used. Fixtures shall be tested for proper operation prior to turn-over and shall be replaced if necessary.

### 3.3 GROUND-MOUNTING LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location.

### 3.4 IN-GRADE LUMINAIRE INSTALLATION

- A. All in-grade fixtures shall be installed per manufacturer's installation instructions.
- B. Verify design type, Flow Through or Sealed, prior to installation.
- C. Flow Through in-grades fixtures shall have drainage system installed below fixture per manufacturer's requirements. If site has poor drainage soil, a sealed in-grade shall be installed. Coordinate soil type with civil engineer prior to submittals.
- D. Provide all conduit connections to in-grade fixture with seal off compound.

### 3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

### 3.6 GROUNDING

- A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems"
- B. Bond luminaires and metal accessories to the grounding system per NEC.
- C. Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.
- D. At each light pole, light column, light bollard and support structures, provide a driven ground rod into the earth so that after the installation is complete, the top of the ground rod will be approximately 1 foot below finished grade. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

### 3.7 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
  - 1. Light fixtures served from multiple power sources, such as emergency fixtures fed from emergency transfer relay or split wired fixtures, shall have the following label affixed to it: "DANGER - ELECTRICAL SHOCK HAZARD - LIGHT FIXTURE HAS MULTIPLE POWER SOURCES"
- B. Manufacturer's Nameplate: Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.
- C. Factory-Applied Labels: Provide labeled luminaires in accordance with UL 1598 requirements. All light fixtures shall be clearly marked for operation of specific LED's and drivers according to proper type. The following characteristics shall be noted in the format "Use Only \_\_\_\_":
  - 1. LED or lamp type, and nominal wattage
  - 2. Driver or ballast type
  - 3. Correlated color temperature (CCT) and color rendering index (CRI)
  - 4. All markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Drivers and ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

### 3.8 FIELD QUALITY CONTROL:

- A. The lighting and lighting controls systems shall be synchronized and fully operable to address the lighting operation in a complete and code-compliant manner.
- B. Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section. Replace defective light fixtures, controls, lamps, ballasts and drivers at no cost to Owner.
- C. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal and emergency power sources.
- D. Illumination Tests:
  - 1. Measure light intensities at night. Use certified photometers with calibration referenced to NIST standards. Record footcandle results and furnish to the Engineer. Comply with the following IESNA testing guide(s):
    - a. IESNA LM-5, "Photometric Measurements of Area and Sports Lighting Installations."
    - b. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
    - c. IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
    - d. IESNA LM-64, "Photometric Measurements of Parking Areas."
    - e. IESNA LM-72, "Directional Positioning of Photometric Data."
- E. Dimming Drivers. Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range. Replace defective light fixtures, controls, lamps, ballasts and drivers at no cost to Owner.
- F. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal. Replace defective light fixtures at no cost to Owner.
- G. Inspect each light fixture for damage. Replace damaged light fixtures at no cost to the Owner.
- H. Fixtures showing dirt, dust or fingerprints shall be restored to like new condition or shall be replaced at no cost.

### 3.9 CLEANING

- A. At completion of each phase and the time of final acceptance by the Owner, all lighting fixtures shall have been thoroughly cleaned with materials and methods recommended by the manufacturer.
- B. All fingerprints, dirt, tar, smudges, drywall mud and dust, etc. shall be removed by the Contractor from the luminaire bodies, reflectors, trims, and lens/louvers prior to final acceptance. Cleaned with solvent recommended by the manufacturer to a like-new condition or replaced. All reflectors shall be free of paint other than factory-applied, if any.



3.10 ADJUSTING

- A. All adjustable luminaires shall be aimed, focused, locked, etc., by the Contractor under the observation of the Architect and Engineer. As aiming and adjusting is completed, locking setscrews and bolts and nuts shall be tightened securely by the Contractor. All aiming and adjusting shall be performed after the entire installation is complete for each phase or area. The Contractor shall be responsible for notifying the Architect of appropriate time for final luminaire adjustment. Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing lighting effects, aiming shall be accomplished at night at no premium cost.
- B. All ladders, scaffolds, lifts, gloves, cleaning cloths, access/adjustment tools, etc. required for aiming and adjusting luminaires shall be furnished by the Contractor.
- C. Occupancy Adjustments: When requested within 12 months of date of Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two (2) visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
  - 1. Adjust aimable luminaires in the presence of Architect/Engineer.

END OF SECTION 265000

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## SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical" apply to this Section.

#### 1.2 SUMMARY

- A. Description: The telecommunications bonding and grounding system and its interconnections to the electrical system provide an electrically continuous, low impedance path for all connected telecommunications equipment and pathways.
- B. Section Includes:
  - 1. Bonding conductors.
  - 2. Bonding connectors.
  - 3. Bonding busbars.
- C. Related Requirements:
  - 1. Refer to Section 260526 "Grounding and Bonding for Electrical Systems" for requirements associated with Electrical System Grounding, Equipment Grounding System, and Grounding Electrode System.

#### 1.3 REFERENCES

- A. Abbreviations
  - 1. TBC: Telecommunications Bonding Conductor.
  - 2. SBB: Secondary Bonding Busbar (Formerly TGB).
  - 3. PBB: Primary Bonding Busbar (Formerly TMGB).
  - 4. RBB: Rack Bonding Busbar
  - 5. TBB: Telecommunications Bonding Backbone
  - 6. BBC: Backbone Bonding Conductor
  - 7. TEBC: Telecommunications Equipment Bonding Conductor
  - 8. RBC: Rack Bonding Conductor
- B. Definitions
  - 1. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.
  - 2. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.

3. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  1. Building Industry Consulting Service International (BICSI)
    - a. ANSI/BICSI N3 “Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure”
  2. Telecommunications Industry Association (TIA):
    - a. ANSI/TIA-607, “Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises”

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product.
- B. Field Quality Control Reports: Provide test reports for each test specified in the field quality control section. Include certificate of current equipment calibration.
- C. Closeout Submittals:
  1. Operation and Maintenance Data: In addition to the items specified in Division 01 and Section 260010 “General Requirements for Electrical” include the following:
    - a. Results of the ground-resistance and bonding resistance tests.
    - b. Include recommended testing intervals

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with NFPA 70, TIA-607, and ANSI/BICSI N3.

#### 2.2 CONDUCTORS

- A. Insulated Copper Conductors: Comply with Section 260519 “Low-Voltage Electrical Power Conductors and Cables”.
  1. Ground wire for custom-length equipment bonding jumpers: minimum No. 6 AWG.

## 2.3 CONNECTORS

- A. Comply with requirements in 260526 “Grounding and Bonding for Electrical Systems”.

## 2.4 TELECOM BONDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
  - 1. Harger Lightning and Grounding
  - 2. Panduit Corp.
  - 3. Erico
  - 4. Chatsworth CPI
  - 5. Ortronics
  - 6. Eaton
- B. General Requirements:
  - 1. Predrilled BICSI/TIA-607 style hole pattern for use with lugs specified in this Section.
  - 2. Mounting Hardware: Stand-off brackets that provide a minimum of 4-inch clearance to access the rear of the busbar. Provide stainless steel brackets and bolts.
  - 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
  - 4. Busbar length: Size to accommodate initial conductors plus a 50% growth factor.
- C. Primary Bonding Busbar (PBB): Predrilled, wall-mounted, rectangular bars of electro-tin plated copper, 1/4 by 4 inches in cross section, minimum 24 inches in length or as indicated on Drawings. NRTL listed for use as PBB, complying with UL 467 and TIA-607.
- D. Secondary Bonding Busbar (SBB): Predrilled, wall-mounted rectangular bars of electro-tin plated copper, 1/4 by 2 inches in cross section, minimum 12 inches in length or as indicated on Drawings. NRTL listed for use as a SBB, complying with UL 467 and TIA-607.
- E. Rack Bonding Bar (RBB): Comply with requirements for rack busbars in Section 271100 “Communications Equipment Room Fittings”.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of TBC connection.
- C. Prepare written report, endorsed by Installer, listing any conditions detrimental to performance of the Work.

- D. Proceed with connection of the TBC only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1, NFPA 70, TIA-607, and ANSI/BICSI N3.

### 3.3 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
  - 1. The bonding conductors between the PBB/SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- B. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
  - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
  - 4. Connections to Structural Steel: Welded connectors.
- C. Conductor Support:
  - 1. Secure grounding and bonding conductors at intervals of not less than 36 inches.
- D. Grounding and Bonding Conductors:
  - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than ten times the diameter of the conductor. No one bend may exceed 90 degrees.
  - 2. Install without splices.
  - 3. Support at not more than 36-inch intervals.
  - 4. Install grounding and bonding conductors in minimum 1-inch Schedule 80 PVC conduit where exposed to physical damage or where routed through building walls or footings. Provide EMT conduit for the grounding and bonding conductor pathway where installed in a plenum.
    - a. If a grounding and bonding conductor is installed in ferrous metallic conduit bond the conductor to the conduit at both ends using a grounding bushing that complies with requirements in Section 270528, "Pathways for Communications Systems".

### 3.4 GROUNDING ELECTRODE SYSTEM

- A. Provide a Telecommunications Bonding Conductor (TBC) between the PBB and the electrical service equipment ground busbar no smaller than No. 1/0 AWG and no smaller than the Telecommunications Bonding Backbone (TBB).
- B. Where external equipment ground busbar is not available, provide intersystem bonding termination (IBT) device for connecting telecommunications bonding conductor (TBC) with service busbar.
- C. Comply with requirements in article 250.94 of the National Electric Code (NEC).

### 3.5 TELECOM BONDING BUSBARS

- A. Provide PBB in main telecommunications equipment room and locate to minimize length of TBC.
- B. Provide SBB in each telecom room.
- C. Install PBB/SBB horizontally, on insulated spacers 4 inches minimum from wall, 48 inches above finished floor unless otherwise indicated.
- D. Install RBB on rack or cabinet using stand-off block insulators to provide a minimum of 0.75 inches of separation for dissimilar metals and to facilitate conductor attachment to RBB. The RBB may be directly mounted/bonded to the rack or cabinet only if doing so allows adequate space for attaching grounding conductors and does not create a dissimilar metals reaction.

### 3.6 CONNECTIONS

- A. Bond all metallic equipment and pathways in each telecommunications room to the bonding busbar in that room, using insulated grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
  - 1. Use crimping tool and the die specific to the connector.
  - 2. Pre-twist the conductor.
- D. Clean and apply an antioxidant compound to all bolted and compression connections.
- E. Building Entrance Protectors: Bond to the PBB/SBB with insulated bonding conductor.
- F. Busbar Interconnections: Interconnect all SBBs with the PBB using a continuous telecommunications bonding backbone (TBB). If more than one TBB is installed, interconnect TBBs using the backbone bonding conductor (BBC) conductor at the top floor and at every third floor in between. The telecommunications bonding backbone and backbone bonding

conductor size shall not be less than 2 kmils/linear foot of conductor length, up to a maximum size of 750 kmil unless otherwise indicated.

- G. Telecommunications Enclosures and Equipment Racks/Cabinets: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Connect the Telecommunications Equipment Bonding Conductor (TEBC) to the Rack Bonding Busbar (RBB) and to the rack/cabinet using a Rack Bonding Conductor (RBC) and listed compression two hole lugs.
- H. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.
- I. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each PBB/SBB to the equipment ground bar of the panelboard.
- J. Shielded Cable: Bond the shield of shielded cable to the PBB/SBB in communications rooms and spaces. Comply with TIA-568.1 and TIA-568-.2 when grounding shielded balanced twisted-pair cables.
- K. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the rack bonding busbar (RBB) using unit bonding conductors (UBC). Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.
- L. Ladder Rack and Cable Tray: Bond ladder rack/cable tray system to the PBB/SBB using manufacturer approved ground lugs and bonding conductors. Remove paint from the ladder rack/cable tray to ensure ground lugs contact bare metal.
- M. Metallic Conduits: In telecommunications rooms, bond metallic conduits longer than 24-inches to the PBB/SBB using insulated ground bushing sized for the conduit and ground conductor to be attached.

### 3.7 IDENTIFICATION

- A. Comply with requirements in Section 270553 - Identification for Communications Systems.

### 3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  - 2. Bond Resistance Test: Test the bonding connections of the system using a certified micro-ohmmeter, taking two-point bonding measurements in each telecommunications equipment room containing a PBB/SBB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.



- a. Measure the resistance between the following:
    - 1) Each PBB/SBB to the nearest electrical equipment ground.
    - 2) Each PBB/SBB to the structural steel.
    - 3) PBB to each SBB.
    - 4) Structural steel to the electrical ground.
  - b. The maximum acceptable value of this bonding resistance is 100 milliohms.
3. Test for ground loop leakage currents using a certified digital clamp-on earth ground tester, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
- a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the PBB and in each SBB. Maximum acceptable ac current level is 1 A.
- B. Excessive Ground Resistance: If resistance to ground at the TBC exceeds 5 ohms, notify Engineer promptly and include recommendations to reduce ground resistance.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 270526

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## SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical Systems”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Conduits and fittings.
  - 2. Metallic surface pathways.
  - 3. J-Hooks.
  - 4. Boxes, enclosures, and cabinets.
- B. Related Requirements:
  - 1. Refer to Section 260543 “Underground Ducts and Raceways for Electrical Systems” for communication system pathway requirements

#### 1.3 REFERENCES

- A. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. Building Industry Consulting Service International (BICSI)
    - a. ANSI/BICSI N1 “Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure.”
  - 2. Telecommunications Industry Association (TIA)
    - a. ANSI/TIA-569, “Commercial Building Standard for Telecommunications Pathways and Spaces”

#### 1.4 SUBMITTALS

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

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS

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

### 2.2 CONDUITS AND FITTINGS

- A. Comply with 260533 “Raceways and Boxes for Electrical Systems”.
- B. Conduit Bodies
  - 1. Telecommunications style with standards based internal bend radius control.

### 2.3 J-HOOKS

- A. Description: Comply with UL 2239, single and multi-tiered prefabricated sheet metal wide base cable supports with integral bend radius support for telecommunications cable.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal:
  - 1. Panduit
  - 2. Legrand
  - 3. Eaton B-Line
  - 4. nVent Caddy
  - 5. Thomas & Betts
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Material: Galvanized steel.
- E. J shape.
- F. UL 2043 listed and suitable for use in air handling spaces.
- G. Pre-riveted assembly allowing for attachment to walls, ceilings, beams, threaded rods, drop wires and underfloor supports to meet requirements of application indicated.

### 2.4 BOXES, ENCLOSURES, AND CABINETS

- A. Comply with 260533 “Raceways and Boxes for Electrical Systems”.

- B. General Requirements for Boxes, Enclosures, and Cabinets used for communications:
  - 1. Minimum Device Box Dimensions unless noted otherwise:
    - a. Minimum 4 inches square by 3-1/2 inches for 1-inch pathways.
    - b. Minimum 4-11/16 inches square by 3-1/2-inch deep box for pathways 1-1/4 inches and larger.
  - 2. Gangable boxes are prohibited.

### PART 3 - EXECUTION

#### 3.1 PATHWAY APPLICATION

- A. Comply with requirements in Section 260533 - Raceways and Boxes for Electrical Systems and Section 260543 – Underground Ducts and Raceways for Electrical Systems for pathway application except as noted herein.
- B. Minimum Pathway Size: 1-inch trade size.
  - 1. For Cat6A cable applications: minimum 1-1/4-inch trade size.
- C. Install surface pathways only where indicated on Drawings or where approved by Engineer.
- D. Use of flexible conduit is prohibited.

#### 3.2 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements indicated on Drawings or in this Section are more stringent:
  - 1. ANSI/BICSI N1.
  - 2. TIA-569.
- B. Comply with requirements in Section 260500 – Common Work Results for Electrical Systems for hangers, supports, and sleeves.
- C. Comply with requirements in Section 260533 - Raceways and Boxes for Electrical Systems for installation of raceways and fittings except as noted herein.
- D. Comply with requirements in Section 260543 – Underground Ducts and Raceways for Electrical Systems for installation of underground duct.
  - 1. Provide fabric innerduct and pull string for all underground duct.
- E. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction.
- F. Utilize manufactured sweeps and long radius elbows for all optical-fiber cables.

- G. Raceways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
1. 1-Inch Trade Size and Larger: Install pathways in maximum continuous lengths of 100-feet.
  2. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
  3. Minimum Bend Radius
    - a. For trade size conduits 2-inch or less, provide inside bend radius at least 6 times the internal diameter of the raceway.
    - b. For trade size conduits greater than 2-inch, provide inside bend radius at least 10 times the internal diameter.
  4. Pull boxes should be readily accessible and should be installed in straight sections of conduit and not used in place of a bend.
  5. Provide a conduit stub-up for each outlet box unless noted otherwise.
- H. J-Hooks:
1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
  2. Provide dedicated support wires, threaded rod, beam clamps, or strut. Do not use ceiling grid support wire or support rods.
  3. Install at spacing intervals to allow no more than 6-inches of slack and to provide a minimum of 6-inches of clearance from the lowest point of the cables to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
  4. Maximum Spacing: 4-feet on center.
    - a. For Cat6A installations: 3-foot on center.
  5. Provide a hook at each change in direction.
  6. Do not exceed load ratings specified by manufacturer.
  7. Do not install J-hooks that cannot be maintained without removal of another system.
  8. Provide additional tiers where required to meet fill capacity and load rating requirements or to separate low voltage systems with varying voltage and power limitations.

### 3.3 PROTECTION

- A. Protect installed cables in open cabling systems:
1. Install temporary protection for cables in open pathways to safeguard exposed cables against paint overspray, falling objects or debris during construction.
  2. Replace any cable exposed to paint overspray or other foreign substance that voids the cable warranty, at no cost to the owner.
  3. Temporary physical protection for cables and J-hooks can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.

END OF SECTION 270528

## SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, Section 260010 “General Requirements for Electrical”, and 270010 “Supplemental Requirements for Communications” apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Wire-mesh cable tray.
  - 2. Cable tray accessories.

#### 1.3 REFERENCES

- A. Abbreviations
- B. Definitions
  - 1. Grounding: Establishing a direct or indirect connection to Earth or some conducting body that serves in place of Earth.
  - 2. Bonding: Method by which all non-energized conductive materials are effectively interconnected to create a low impedance path.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
  - 1. Building Industry Consulting Service International (BICSI)
  - 2. ANSI/BICSI N1 “Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure.”
  - 3. National Electrical Manufacturer’s Association (NEMA)
    - a. NEMA VE 1 “Metal Cable Tray Systems”
    - b. NEMA VE 2 “Cable Tray Installation Guidelines”
  - 4. Telecommunications Industry Association (TIA)
    - a. ANSI/TIA-569, “Commercial Building Standard for Telecommunications Pathways and Spaces”

## 1.4 SUBMITTALS

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

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS FOR CABLE TRAYS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
- B. Source Limitations: Obtain cable trays, components, and accessories from single manufacturer.
- C. Sizes and Configurations: Refer to Drawings for specific requirements for types, materials, sizes, and configurations.

### 2.2 WIRE-MESH CABLE TRAY

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton B-Line
  - 2. Cablofil
  - 3. Chatsworth
  - 4. MP Husky
  - 5. Siemon
  - 6. Snake Tray
  - 7. nVent WBT Tray
- B. Description:
  - 1. Configuration: steel wire mesh, complying with NEMA VE 1.
  - 2. Minimum Width: 12 inches unless otherwise indicated on Drawings.
  - 3. Minimum Usable Load Depth: 4 inches unless otherwise indicated on Drawings.
  - 4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
  - 5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
  - 6. Splicing Assemblies: UL classified bolted type, using serrated flange locknuts.
  - 7. Splice-Plate Capacity: UL Classified splices located within support span shall not diminish rated loading capacity of cable tray.
- C. Materials and Finishes:
  - 1. Steel:
    - a. ASTM A 1011/A 1011M for 14 gage and thicker; ASTM A 1008/A 1008M for 16 gage and thinner.



- b. Straight Sections and Fittings: Comply with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
- c. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
- d. Fasteners: Comply with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
- e. Finish: Electrogalvanized after fabrication, complying with ASTM B 633 for use in indoor locations.
  - 1) Hardware: Galvanized, ASTM B 633.

## 2.3 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings indicated, of same materials and finish as cable tray.
- B. Barrier Strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

## 2.4 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

# PART 3 - EXECUTION

## 3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to BICSI N1, NEMA VE 2, and TIA-569.
- B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable trays to provide a minimum of 12-inch clear space above the top of the cable tray for cable installation.
- D. Install cable trays with enough horizontal workspace to permit access for installing cables.
- E. Install cable trays so all splices are accessible for inspection and adjustment.
- F. Install cable trays to provide a minimum of 3-inch (6-inch recommended) clear space above ceiling tile and grid.
- G. Remove burrs and sharp edges from cable trays.
- H. Fasten cable tray supports to building structure.

- I. Design fasteners and supports to carry cable tray, number of cables at full capacity, and a concentrated load of 200 lb. Comply with requirements in Section 260500 – Common Work Results for Electrical Systems.
- J. Place supports so spans do not exceed maximum spans and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- K. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- L. Support assembly to prevent twisting from eccentric loading.
- M. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice point between supports.
- N. Support wire-basket cable trays with trapeze hangers, or wall brackets.
- O. Support trapeze hangers for wire-basket trays with minimum 1/4-inch diameter rods.
- P. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- Q. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
- R. Make changes in direction and elevation using manufacturer's recommended fittings and integral bend radius control.
- S. Make cable tray connections using manufacturer's recommended fittings.
- T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- U. Where indicated, install permanent covers, after installing cable. Install cover clamps according to NEMA VE 2. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

### 3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 - Grounding and Bonding for Communications Systems.
- B. Bond cable trays together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing

splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

### 3.3 CABLE INSTALLATION

- A. Install cables after each cable tray run has been completed and inspected.
- B. Initial fill ratio shall not exceed 25%.
- C. Initial cable fill shall not exceed 50% of the manufacturer's listed load rating.
- D. Fasten cables on vertical runs with cable clamps or cable ties every 18-inches according to NEMA VE 2. Fasten cables on horizontal runs where required to maintain a neat and workmanlike installation.
- E. Tighten clamps and ties only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device and trim excess to prevent further tightening.
- F. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.
- G. Provide radius drop-outs wherever multiple cables are existing the cable tray.
- H. In existing construction, remove inactive or dead cables from cable trays.

### 3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect pathways to cable trays according to requirements in NEMA VE 2.

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections
  - 1. After installing cable trays, provide visual survey for compliance with requirements.
  - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
  - 3. Verify that communications cabling is separated from power circuits by barriers or are installed in separate cable trays.
  - 4. Verify there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
  - 5. Remove dust deposits, trash of any description, and any blockage of tray ventilation.

6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

### 3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against paint overspray, falling objects, or debris during construction.
2. Replace any cable exposed to paint overspray or other foreign substance that voids the cable warranty, at no cost to the owner.
3. Temporary physical protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
4. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
5. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

## SECTION 275116A - SCHOOL SOUND REINFORCEMENT SYSTEMS – GYM AND CAFETERIA

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 “General Requirements for Electrical Systems” apply to this Section.

#### 1.2 SUMMARY

- A. Description: A complete and fully functional sound reinforcement system that is durable, intuitive, easy to operate, compatible with any future components, and suitable for the following applications:
  - 1. Gymnasiums
  - 2. Cafeterias
- B. Section Includes:
  - 1. Amplifiers
  - 2. Loudspeakers
  - 3. Mixer/Preamplifier
  - 4. Equalizer
  - 5. Media Players
  - 6. Microphones
  - 7. Cabling and Connectors
  - 8. Power and Surge Suppression
  - 9. Assisted Listening System
- C. Related Requirements:
  - 1. Refer to other Division 27 sections for telecommunication requirements related to data LAN connections and building horizontal cable.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. DSP: Digital Signal Processing
  - 2. NC: Noise Criterion
  - 3. SPL: Sound Pressure Level
  - 4. STI: Speech Transmission Index
  - 5. THD: Total Harmonic Distortion

B. Definitions

1. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
2. Reverberation Time: The time that would be required for the reverberantly decaying sound pressure level in the enclosure to decrease by 60 decibels.
3. Zone: A group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.

1. Audiovisual and Integrated Experience Association (AVIXA)
  - a. AVIXA A102.01, "Audio Coverage Uniformity in Listener Areas"
  - b. ANSI/AVIXA D401.01, "Standard Guide for Audiovisual Systems Design and Coordination Processes"
  - c. AVIXA F501.01, "Cable Labeling for Audiovisual Systems"
  - d. AVIXA F502.01, "Rack Building for Audiovisual Systems"
  - e. AVIXA F502.02, "Rack Design for Audiovisual Systems"
  - f. AVIXA 10, "Audiovisual Systems Performance Verification"

1.4 PREINSTALLATION MEETINGS

- A. Schedule preconstruction conference with Architect, Owner, and all affected trades. Agenda topics should include, but are not limited to, the following:
1. System installation schedule and sequencing.
  2. Site readiness requirements.
  3. Equipment delivery and site security.
  4. System programming and user group requirements.

1.5 SUBMITTALS

- A. Product Data: Submit for each type of product specified.
- B. Shop Drawings: For sound system and related equipment.
1. Include floor plans drawn to scale which show locations of all devices and equipment. Indicate electrical power connections, approximate location and size of conduit/wiring runs, and other information required to clearly describe the proposed system.
  2. Include identification numbers and wiring connections for all equipment and devices in entire system. Identify loudspeaker mounting height and vertical/horizontal aiming.
  3. Include enlarged plans, drawn to scale, for all equipment rooms with dimensioned equipment layouts.
  4. Include scaled elevations to describe equipment arrangements for racks and cabinets.

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5. Functional Block and Wiring Diagrams: Detail all equipment with wire and connections for power, signal, and control. Clearly differentiate between factory installed wiring and field installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.
  6. Include details of all connector plates.
  7. Installation details for loudspeaker support structures and mounting brackets.
- C. Delegated-Design Submittal: For loudspeaker supports
- D. Qualification Data: For qualified installer.
- E. Field Quality Control Reports
1. Test procedures and equipment used.
  2. Graphical or numerical test results that show conformance with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Closeout Submittals
1. Operation and Maintenance Data: For sound system and components to include in operation and maintenance manuals.
  2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Operating instructions and block diagrams laminated and mounted to the inside of the equipment cabinet. Detail the theory of operation, narrative descriptions, and pictorial illustrations.
- 1.6 QUALITY ASSURANCE
- A. Manufacturer Qualifications:
1. Five continuous years, minimum, design and manufacture of the materials and equipment specified.
  2. Manufacturing facilities certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.
  3. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, maintenance, emergency repairs to equipment, and response times less than eight hours.
  4. Employ trained staff that are available 24/7 to provide scheduling support and assist with reporting needs.
- B. Installer Qualifications:
1. Manufacturer's authorized representative who is trained and certified by the manufacturer for installation of the specified product.
  2. Minimum of five years successful installation experience with Projects of similar size and complexity.
  3. Upon request, be able to provide a minimum of three reference accounts at which similar work, both in scope and complexity, have been completed by The Contractor within the last three years.

4. Project Personnel Requirements: Installer must have the following certified full-time employees on staff and assigned to the project:
5. All personnel must be trained and certified by the manufacturer for installation of units required for this Project.
  - a. System Designer: Preparation of shop drawings, cabling administration drawings, and field-testing program development by a CTS-D certified technician (or equivalent NICET certification) trained and certified in audio visual system design by the approved manufacturers within the last 36 months.
  - b. Lead Technician: Provide a CTS-I certified technician who shall supervise installation of all devices, connections, and programming for the sound system. Technician shall be certified by the approved manufacturer within the last 36 months. The lead technician shall be present at all times when work of this Section is performed at the project site.
  - c. Technicians: Personnel installing any part of the work related to this section shall be trained and certified by the approved equipment manufacturer within the last 24 months.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Storage and Handling Requirements: Comply with manufacturer instructions for storage of electrical equipment to prevent damage from condensation or other environmental factors.

#### 1.8 WARRANTIES

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace components of sound system and all associated components that fail in materials or workmanship within 1 year of Substantial Completion.

### PART 2 - PRODUCT

#### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Equipment identified by part number and manufacturer are to establish acceptable quality and performance desired for this system.
  1. For items identified by part number and manufacturer, performance specifications published in the most recent manufacturer's data sheets available at the time of bidding this contract shall apply to the work as specified.
  2. For those items that are not identified by part number and manufacturer, select items that conform to the functional and technical specifications required to support the performance of the system.
- C. Equipment: Suitable for mounting in a standard 19-inch EIA rack.



## 2.2 SYSTEM PERFORMANCE REQUIREMENTS

- A. Signal to Noise Ratio: Capable of an acoustic output SPL of at least 25dB above ambient noise level in each octave band. For spaces with high ambient noise conditions (above 35 dB), 15 dB S/N ratio is recommended.
- B. System Frequency Response: 20-Hz to 20-kHz, plus or minus 0.5 dB.
- C. THD: 1-percent maximum from 20-Hz to 20-kHz measured at the output of any speaker.
- D. Headroom: Plus or minus 20 dB above nominal SPL, without increase in hum, noise, THD, or frequency response.
- E. Hum and Noise: 80 dB below nominal SPL.
- F. Power Capacity: 50-percent greater than power output at nominal SPL.
- G. Crosstalk
- H. Speech Transmission Index (STI): minimum 0.58 in listener areas.

## 2.3 OPERATION

- A. Interface will be intuitive and easy to operate.
- B. Interface will remain compatible with any future components.
- C. Input controls must not rely on software and will not require any maintenance or updates.
- D. Components are built tough to withstand the conditions of the installed environment.
- E. Powerful, full coverage

## 2.4 LOUDSPEAKERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. Renkus-Heinz
  - 2. Community
  - 3. RCF
  - 4. Atlas Sound
- B. General Characteristics
  - 1. Enclosure: Cabinet
  - 2. Input Connections: Screw terminal blocks.
  - 3. Enclosure: Suitable for installed operating environment.
  - 4. Integral rigging points suitable for use with manufacturers standard mounting brackets.

## 2.5 RIGGING AND SUPPORT STRUCTURES

- A. Delegated Design: Engage a qualified professional engineer, to design attachments, rigging, and support structures.
  - 1. Minimum safety factor for structural support members: 5:1.
  - 2. Minimum safety factor for hardware, attachments, and safety wire: 8:1.

## 2.6 EQUIPMENT

- A. Stereo Power Amplifier
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
    - a. Crown
    - b. Powersoft
    - c. QSC
    - d. Crestron
  - 2. General Characteristics
    - a. Class D
    - b. Rack mountable
    - c. 2-channel minimum
    - d. 4, 8-ohm bridge
    - e. Gain selection switches
    - f. Input: 3 pin XLR and 1/4-inch TRS
    - g. Output: Binding post and NL4
    - h. Built in Digital Signal Processing
- B. Rackmount Mixer
  - 1. Inputs: 8 balanced line level
  - 2. Frequency Response: 15Hz to 55 kHz, plus or minus 3db.
- C. Digital Media Player
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
    - a. Denon
    - b. Tascam
    - c. Numark
  - 2. General Characteristics
    - a. Capable of playing digital media files from the following
      - 1) DVD and Blu-Ray discs.
      - 2) CD discs using WAV/MP3/AAC file formats.
      - 3) Portable devices connected to a USB host port.
      - 4) Portable devices connected to a 3.5mm AUX input.
      - 5) Bluetooth paired device.
    - b. Balanced XLR and unbalanced RCA audio outputs.
    - c. HDMI audio/visual outputs.
    - d. RS-232c control capable.

## 2.7 MICROPHONES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. Shure
  - 2. Electro-Voice
  - 3. Audio-Technica
- B. Wired Handheld Microphones
  - 1. Type: Dynamic
  - 2. Frequency Response: 50 to 15,000 Hz
  - 3. Polar Pattern: Cardioid
  - 4. Connector: 3-pin male XLR
  - 5. On/Off Switch
- C. Wireless Handheld Microphones
  - 1. Working Range: 300 feet
  - 2. 470MHz to 680 MHz transmitter frequency range
  - 3. 100 mW (nominal) RF transmitter power source
  - 4. Power: Rechargeable Lithium-Ion battery
  - 5. Charging Station
  - 6. On/Off Switch
  - 7. Antenna
  - 8. Receiver

## 2.8 CABLING AND CONNECTORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. Belden
  - 2. Switchcraft
  - 3. West Penn.
- B. Faceplates: Stainless Steel
  - 1. Jacks: Interlocking with microphone cable
- C. Cable
  - 1. Microphone: XLR- type, 25ft minimum
  - 2. Speaker

## 2.9 CABINETS

- A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting with an opening of 17.72 inches between rails.

- B. Manufacturers: Subject to compliance with requirements, provide product indicated or approved equal by one of the following:
1. Belden
  2. Chatsworth CPI
  3. Great Lakes
  4. Ortronics
  5. Middle Atlantic
  6. Panduit
  7. Siemon
- C. General Cabinet Requirements:
1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
  2. Material: Steel.
  3. Finish: Manufacturer's standard, baked-polyester powder coat.
  4. Color: Black.
- D. Modular Wall Mounted Cabinets:
1. Height: 36 inches or as indicated on Drawings.
  2. Depth: 30 inch minimum.
  3. Load Rating: 200 lb minimum.
  4. Number of Rack Units: 18U or as indicated on Drawings.
  5. Threads: #12-24 universal hole pattern.
  6. Dual Hinged swing out body
  7. Lockable front and rear doors.
  8. Louvered side panels.
  9. Knockouts for conduit or cable entry grommets in top and bottom rear.
  10. Integral lashing brackets and vertical cable management.
  11. Grounding lugs.
  12. Horizontal RBB.
  13. Side-mounted, minimum 100-cfm fan.
  14. All cabinets keyed alike.
  15. Bonding wires for all panels.
- E. Rack and Cabinet Bonding Busbars (RBB): Rectangular bars of electro-plated copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-C. Predrilling shall be with holes for use with lugs specified.

## 2.10 POWER AND SURGE SUPPRESSION

- A. Manufacturers: Subject to compliance with requirements, provide product indicated or approved equal by one of the following:
1. Tripp Lite
  2. Panduit
  3. Leviton
  4. Chatsworth CPI

5. Middle Atlantic
6. Geist
7. Siemon

B. Power Distribution Unit: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting.
3. Height: 1 RU.
4. Housing: Metal
5. Minimum Two front-facing 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R and Ten rear facing 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
6. LED indicator lights for power and protection status.
7. LED indicator lights for reverse polarity and open outlet ground.
8. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
9. Cord connected with 10-foot line cord.
10. Rocker-type on-off switch, illuminated when in on position.
11. Surge Protection: UL 1449, Type 3.
  - a. Maximum Surge Current, Line to Neutral: 96 kA and neutral to ground.
  - b. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall not be more than 330 V.
  - c. EMI/RFI noise filtering: 40-80dB.
  - d. AC Suppression Joule Rating: 3800 J minimum.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
  1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine raceway rough-in and electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 CABLING AND CONDUCTOR APPLICATION

- A. Provide protection for exposed cables where subject to damage.
- B. Use suitable cable fittings and connectors.

- C. Provide cable listed for wet locations where routed outdoors or in/under concrete slabs on grade.

### 3.3 INSTALLATION

- A. Wiring Methods: Install all cabling in raceway, minimum 3/4-inch, in accordance with Section 260533, "Raceways and Boxes for Electrical Systems" and manufacturer's recommendations. Conceal raceway, except in unfinished spaces.
  - 1. Install plenum rated cable in environmental air spaces, including plenum ceilings.
- B. Wiring and Cabling Installation
  - 1. Install wiring and cable in a continuous manner, do not splice cable between termination, tap, or junction points.
  - 2. At device outlets, provide 12-inches of excess cable and coil cables in the outlet boxes without exceeding the cable bend radius.
  - 3. At equipment enclosures, provide 6-feet of excess cable and dress/store with cable management without exceeding cable bend radius.
  - 4. Install cable management to restrain cables, prevent straining connections, and maintain minimum bending radius.
  - 5. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation, and replace it with new cable.
  - 6. Within enclosures, bundle cables by the following signal types. Do not mix circuits in the same bundle. Where not in enclosures, provide separate raceways for signal types.
    - a. Microphone level signal circuits.
    - b. Line level audio signal circuits.
    - c. Loudspeaker signal circuits.
    - d. Video signal circuits
    - e. Control, data, and communication signal circuits
    - f. Power circuits.
  - 7. Separate pathways for power circuits at least 12-inches from other signal circuits to avoid EMI.
- C. Follow manufacturer's instructions for installing, operating, configuring, and programming equipment.
- D. Mount racks and cabinets plumb, level, and square without distortion.
- E. Install and arrange system cabinets in accordance with AVIXA F502.01, F502.02, and manufacturer's instructions to ensure adequate ventilation and service access.
  - 1. Provide ventilation where required to maintain equipment within the manufacturer's specified temperature limits. Select and locate fans to minimize noise impact in the area.
  - 2. Arrange amplifiers per manufacturer instructions with appropriate spacing and ventilation above and below.
  - 3. Allow a minimum 20 percent open rack space.
  - 4. Provide rear support for rack mounted equipment greater than 15" deep.
  - 5. Fill all empty spaces with blank panels, sizing as required, painted to match housing.
  - 6. Locate operator useable equipment and patch panels at an appropriate operating height.
  - 7. Key all door locks for each housing type (front, rear) alike.

- F. Loudspeaker Installation
  - 1. Mount or suspend loudspeakers at the appropriate position in a safe, secure, and permanent manner in accordance with the stamped delegated design drawings.
  - 2. Install mounting system to enable adjustment of aiming direction in plus or minus 5 degree increments.
  - 3. Install safety cable to secure loudspeaker to the building structure.
- G. Leave 12-inches of cable at each termination for microphone, volume controls, speaker, and other system outlets.
- H. Leave 6-feet of excess cable at each termination at system cabinet.
- I. Speaker lines in Gyms and Cafeterias shall be paralleled at the Amplifier and NOT at the speakers.
- J. Provide surge protection devices on all stadium public address system cables that enter or leave the press box.
  - 1. Provide surge protection device on 120-volt power circuit serving the stadium public address consol.
- K. Emergency and Paging System Interface
  - 1. Provide priority control device to interface public address and/or emergency systems with system mute control ports.
  - 2. Mute program audio when system detects audio signal in public address or life safety system for duration of announcement.

### 3.4 GROUNDING AND BONDING

- A. Ground audio cable shields only at the power amplifier inputs. Terminate shields at the "floating" end with insulating collars or heat shrink tubing. Preserve continuity of shields at connecting points. Connect all audio grounds in this system to a common point at a rack bonding busbar.
- B. Connect rack bonding busbar to the telecommunication bonding system and to the rack using listed compression two-hole lugs in accordance with requirements in Section 270526 - Grounding and Bonding for Communications Systems.

### 3.5 IDENTIFICATION

- A. Comply with requirements in Section 270553, "Identification for Communication Systems".
  - 1. Identify system components, wiring, cabling, and terminals. Identify all wiring at terminal and junction locations.
  - 2. Identify all connector plates with consistent input and output designations. Provide engraving only after approval by Engineer and Owner's Representative.

### 3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative. Comply with AVIXA 10 test and measurement procedures.
- B. Visual and Mechanical Inspection
  - 1. Examine equipment and confirm proper identification and labelling.
  - 2. Inspect the physical, electrical, and mechanical condition of the equipment and all components in accordance with the manufacturers' instructions.
  - 3. Visually inspect cable placement, cable bend radius, cable terminations, grounding and bonding, and labeling of all components. Ensure all connectors are fully seated and lock screws are fully tightened.
  - 4. Visually inspect equipment enclosure anchorage, alignment, and grounding.
  - 5. Confirm individual components are installed and performing under provisions of each manufacturer's published specifications.
  - 6. After running performance testing, verify the temperatures in the equipment enclosures are within tolerances defined by the manufacturer's guidelines.
- C. Electrical Tests:
  - 1. Test each rack/cabinet AC power outlet for proper connections to current carrying conductors, grounded conductors, and grounding conductors.
  - 2. Measure and record the DC resistance between the following using a two-point bonding test. Resistance should be 0.15 ohms or less.
    - a. Each rack or cabinet bonding busbar to the nearest electrical equipment ground.
  - 3. Cable Testing: Using a cable tester, test each cable path for positive continuity, cross wiring, loose contacts, open circuits, leakage between wires, and short between wires or to ground.
- D. Audio System Performance Tests and Inspections:
  - 1. Loudspeaker Testing:
    - a. Impedance: Use an impedance meter to test each loudspeaker cable at the amplifier and verify the measurements are not below the predicated impedance.
    - b. Zoning: Pass audio test signal or program audio material through each line individually to verify loudspeakers are zoned correctly.
    - c. Physical Alignment: Check each loudspeaker to verify proper mounting location, mounting height, and vertical and horizontal aiming.
    - d. Polarity: Test each audio path with an impulse tone to verify all loudspeakers have proper polarity.
  - 2. Microphone Testing: Connect microphones and setup in room where it will normally be used.
    - a. Feedback: Using a pink noise source, playback audio in the listening area at a level equal to the microphone dB level. Mute the pink noise and verify feedback or ringing is detected. Unmute the noise source and raise the level at 3-dB increments, muting each time to determine if feedback is present.
    - b. Level Alignment: Verify calibration of microphone inputs so that the difference between any input signal level after the first common gain adjustment is no more than plus or minus 1 dB.
    - c. Wireless Microphones: Confirm transmitter/receiver frequencies, channels, and range are in conformance with manufacturer's requirements.



3. Program Source Audio Alignment: Align all audio program source levels at the first common gain adjustment to establish unity gain and ensure there is no hiss, hum, or distortion on the audio system. Verify the common signal level at the output complies with system performance requirements.
4. System Noise: Verify there is no audible noise on the system by performing the following tests on each loudspeaker individually:
  - a. Rattle: Use a continuous sweep signal operating at 3dB below onset of distortion and verify there is no undesired acoustically induced noise, such as equipment vibration.
  - b. Buzz: With all equipment on and audio level set to 3dB below onset of distortion, verify there is no audible noise within the system from conditions such as unbalanced input pick-ups or stray EMI signals.
5. System Sound Pressure Level and Ambient Noise:
  - a. Ambient Noise: With HVAC and other building systems operating under normal conditions, use a SPL spectrum analyzer to measure background noise levels throughout the space. Record measurements at each test position. Notify Architect and Engineer if A-weighted SPL level exceeds 35 dB.
  - b. Using the same test positions, measure the sound system SPL. Verify the system SPL exceeds the ambient noise level as defined by the performance requirements.
6. Frequency Response and System Equalization: Use a pink noise generator or sine wave sweep generator connected to a system input and a sound analyzer to measure the following:
  - a. Compare system input and output signals for proper frequency response curve conforming with performance requirements. Any input or output signal processing should be bypassed to achieve accurate results.
  - b. Measure loudspeaker output with a measurement microphone to ensure the system can accurately reproduce the audio source frequency response to within +/- 3dB at a distance of 3.3-feet on axis. Analyze a minimum of four different microphone locations.
7. Total Harmonic Distortion: Use an audio test generator to produce a 1 kHz sine wave at the system input and perform a spectral analysis on the output to provide the level of each harmonic and a root mean square (RMS) summation to calculate the THD.
8. DSP Programming: Verify all DSP components have been programmed as required to achieve performance criteria and system functionality.

E. Functional Acceptance Testing

1. Operational Test: Perform tests that include originating program and speech messages at microphone outlets, preamplifier program inputs, and all other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
2. Test all system control functions to verify each input and function activates the proper system response.
3. Activate paging and emergency systems to ensure audio system is muted for duration of announcement or duration of emergency system operation.
4. Assistive Listening System: Verify functionality of assisted listening system in accordance with manufacturer's instructions.

F. Products will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.

- G. Test and Inspection Reports: Prepare a written report to certify compliance with test parameters and record the following:
1. Test procedures used.
  2. Results that comply with requirements.
  3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
  4. Record adjustable settings and measured insulation resistances, time delays, and other values and observations

### 3.7 ADJUSTING

- A. Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
1. Arrange with Owner's representative for period of complete quiet for testing and adjustments to the sound system. These periods may occur at night.
  2. Perform adjustments, equalization, time delay and balancing to prepare the sound system for Owner's use.
- B. Post-Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

### 3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain sound systems.
- B. Training shall consist of not less than 4 hours of onsite hands-on instruction for a minimum of four attendees. Training shall cover the following topics at a minimum:
1. Theory of operation.
  2. Operation of system and components.
  3. Maintenance and configuration.
  4. Troubleshooting and Repair.
  5. Replacement of components.

END OF SECTION 275116

## SECTION 275123 - IP INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: Microprocessor-switched two-way hybrid IP network-based intercommunications and program system.
- B. Section Includes:
  - 1. Main System Console.
  - 2. Graphic User Interface
  - 3. Administrative Consoles.
  - 4. Call Stations.
  - 5. IP and Analog Loudspeakers.
  - 6. Power Amplifiers.
  - 7. Conductors and Cables.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. dB: Decibels
  - 2. DHCP: Dynamic Host Configuration Protocol.
  - 3. FXO: Foreign eXchange Office.
  - 4. GUI: Graphic User Interface
  - 5. H.323: Audio and Video Protocol.
  - 6. PSTN: Public Switched Telephone Network.
  - 7. SIP: Session Initiation Protocol.
  - 8. SPL: Sound Pressure Level.
  - 9. STI: Speech Transmission Index.
- B. Definitions
  - 1. Intelligibility: The quality of the content of a speech message that can be understood, comprehensible or clear.
  - 2. Listening Plane: The distance above the floor to the average audience member's ears across a listening area.
  - 3. Zone: A group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. National Electrical Manufacturers Association (NEMA)
  - a. NEMA SB 40, "Communications Systems for Life Safety in Schools"
  - b. NEMA SB 50, "Emergency Communications Audio Intelligibility Applications Guide"

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Provide the following.
1. Include plans, elevations, sections, and mounting details.
  2. Equipment arrangements for racks and cabinets.
  3. Wiring Diagrams: Detail all wire for power, signal, and control. Clearly differentiate between factory installed wiring and field installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.
- C. Qualification Data: For qualified installer.
- D. Field quality control reports: Indicate all test methods and results.
- E. Closeout Submittals
1. Operation and Maintenance Data: For sound system and components to include in operation and maintenance manuals.
  2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Operating instructions and wiring diagrams laminated and mounted to the inside of the equipment cabinet.
    - b. All final device settings.

#### 1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Regularly engaged in the manufacture of integrated communication systems, master clock systems, and ancillary equipment, of types and capacities required, whose products have been used in similar service for no less than five years.
- B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for design, installation, and programming of units required for this Project:
1. Maintain a fully staffed and equipped service office within 100 miles of the project site that regularly offers maintenance and service for systems of similar design and size.

## 1.6 WARRANTIES

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace intercommunication system equipment and components that fail in materials or workmanship for a period of 5 years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. Telecor eSeries
  - 2. Bogen E7000
  - 3. Valcom IP6000

### 2.2 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to the authority having jurisdiction, and marked for intended location and application.
- B. Equipment: Comply with UL 813.
  - 1. Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated.
  - 2. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz in a satisfactory manner without the requirement of any external power conditioning equipment.
- C. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.
- D. Integration: Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- E. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

### 2.3 SYSTEM FUNCTIONAL DESCRIPTION

- A. Topology: Provide a system with a decentralized network structure not requiring any head-end equipment, central server, or any other control hardware to maintain system operation.
- B. Audio Communications:
  - 1. Provide full duplex two-way voice communication for intercom channels.
  - 2. Provide for unlimited number of simultaneous conversations at any time between pairs of intercom stations, intercom station to console, console to console, console to speaker or

- 
- zone of speakers, program source to a speaker or zone of speakers, or bell tones to a speaker or zone of speakers regardless of number of stations or consoles.
3. The system shall distribute High-Definition Audio throughout listening area to assure maximum intelligibility during paging and live audio playback.
- C. Schedules: Allow users to configure multiple schedules per facility, with an unlimited number of programmable events in each schedule. Scheduled events shall sound a user selectable tone, play a user provided audio file, or play an external program source.
1. Scheduled events shall be directed to any one or more Time Zones in the systems.
  2. Tones: Activated through scheduled events and/or manually activated from administrative consoles or selected SIP phones residing on the telephone system.
  3. Integral master clock: Provide time synchronization to all devices throughout the school. Obtain a time synch signal from an NTP time server via the LAN and automatically adjust the daylight savings time for any defined time zone.
- D. Web Interface: All scheduling assignments shall be performed by a password protected Graphical User Interface (GUI) accessible through a network connected PC.
- E. Network Configuration: All IP network intercom devices shall receive power and data through a Power-Over-Ethernet switch. Once plugged into the LAN through a Power-over-Ethernet network switch, all networked devices shall be immediately operational and, as applicable shall be able to place or receive calls and pages from Stations as well as page all devices in the network. Consoles, intercom stations, clocks, emergency displays, or speakers connected to the network shall not require any network configuration or administration to function.
- F. Telephone Interface: Capable of routing calls from a PSTN into any room, zone, or the entire facility via the SIP enabled Telephone System. Allow for remote monitoring and two-way voice communications from outside the facility to rooms as well as paging into areas of the facility. Provide the following additional features:
1. The ability to place call-ins from call stations to SIP telephones.
  2. The ability to initiate calls from SIP telephones to specific speakers.
  3. The ability to initiate zone and all call paging announcements from SIP Telephones to speakers throughout the facility.
  4. The ability to make outside calls from Administrative Consoles to the PSTN via a district-wide telephone system.
- G. Each station or loudspeaker shall be assignable to all or any combination of paging or program distribution zones in the system.
- H. SMS and Email Notifications: Automatically distribute SMS and email notifications during the following:
1. Notify relevant staff members when an emergency event is occurring in the facility.
  2. Notify appropriate technical support staff in the event that the system is experiencing a fault.
- I. Call Escalation
1. Provide ability to escalate a console call-in and redirect to a secondary destination via the SIP interface.

2. If both the primary and secondary call destinations are unavailable, redirect the call to a back-up station or console.
3. Include the ability to redirect the call to any location on the publicly switched telephone network, landline, or cellular number through the SIP interface via the PBX.

J. Supervision:

1. Provide local, visual indication of failed operation or failed communication of field devices and immediately annunciate a loss of communication or fault condition at the main console.

## 2.4 MAIN CONSOLE

- A. SIP Interface: Supervised and connected to the building/PBX network to establish a gateway between the intercom network and the PBX network. Include the following features:
1. Paging access from any telephone on the facility system VoIP PBX to any intercom speaker, speaker zone, console, all speakers, or all zones throughout the facility.
  2. Activation of all intercom system tones and pre-recorded announcements from any phone connected to the building VoIP PBX phone system.
  3. Ability to require security access code to utilize the intercom system communication features.
  4. Allow for calls to be placed from an administrative console to any phone number on the publicly switched telephone network.
- B. Display and Controls
- C. Modules
- D. Power
- E. Enclosure
1. Sized to house all components required by this specification plus 20% spare for additions.
- F. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system.

## 2.5 LOUDSPEAKERS

- A. IP Network Talkback Loudspeaker
1. Size: 8 inches with 3/4-inch voice coil.
  2. Minimum Axial Sensitivity: 96 dB at one meter, with 1-W input.
  3. Frequency Response: Within plus or minus 3 dB from 30 to 15,000 Hz.
  4. Minimum Dispersion Angle: 100 degrees.
  5. Power Source: Power-over-Ethernet, IEEE 802.3af compliant, Class 0, 5.5W
  6. Networked audio and power interface: RJ45 connector.

7. Microphone: Omni Directional, suitable for low noise applications, with built in compression and noise gate.
8. Call Station Integration: support connection up to two call stations.
9. Satellite Speakers: support up to 4W of additional 25V paging speaker load.
10. Relays: Switched DPDT contacts to support auxiliary functions or visual notification devices.
11. Enclosures: Steel housings or back boxes, acoustically dampened, with steel front face and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting as required; with relief of back pressure.
12. Baffle: For flush speakers, 13-inch round steel with textured white finish.

B. Cone-Type Paging Loudspeakers

1. Size: 8 inches with 1-inch voice coil and minimum 5-oz. ceramic magnet.
2. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
3. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.
4. Minimum Dispersion Angle: 100 degrees.
5. Line Transformer: Minimum 4W, 25/70V, maximum insertion loss of 0.5 dB, and at least four field-selectable level taps.
6. Audio Connection: Color coded, pre-tinned leads.
7. Enclosures: Steel housings or back boxes, acoustically dampened, with steel front face and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting as required; with relief of back pressure.
8. Baffle: For flush speakers, 13-inch round steel with textured white finish.
9. Vandal-Proof, High-Strength Baffle: Where indicated, for flush or surface-mounted speakers, self-aging cast aluminum; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.

C. Horn-Type Paging Loudspeaker

1. Compression type, double re-entrant type with voice coil.
2. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.
3. Minimum Axial Sensitivity: 110 dB at one meter, with 1-W input.
4. Frequency Response: Within plus or minus 3 dB from 450 to 15,000 Hz.
5. Minimum Dispersion Angle: 110 degrees.
6. Line Transformer: Weatherproof, minimum 15W, 25/70V, maximum insertion loss of 0.5 dB, and at least four field-selectable level taps.
7. Audio Connection: Screw terminals.
8. Enclosures: Where indicated, capable of flange mounting to steel wall baffle and standard size steel enclosure.

## 2.6 POWER AMPLIFIERS

- A. Output Power: Class D, 25V/70V balanced line, 2 or 4 channels, each sized for the sum of wattage settings of each station and speaker connected in all-call mode of operation, plus a 25 percent allowance for future stations.



- B. Total Harmonic Distortion: Less than 0.5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.
- C. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
- D. Frequency Response: Within plus or minus 2 dB from 50 to 15,000 Hz.
- E. Output Regulation: Maintains output level within 1 dB from full to no load.
- F. Controls:
  - 1. On-Off power switch (illuminated),
  - 2. Gain Control,
  - 3. Low Cut Switch,
  - 4. Input Level Switch.
- G. GUI based Integral DSP
  - 1. 16-band Graphic Equalizer.
  - 2. Signal Present and Clip Monitor.
  - 3. Adjustable High Pass, Low Pass, and Bandpass Filters.
  - 4. Noise Gate.
  - 5. Compressor/Limiter.
  - 6. Delay; Peak Limiter.
  - 7. Speaker Presets.
  - 8. RMS Limiter; Status.
  - 9. 7-band Parametric Equalizer
- H. Amplifier Protection:
  - 1. Foldback current limitation.
  - 2. Fused primary circuit.
  - 3. Thermal sensor to prevent damage from overloads, shorted line conditions, or excessive heat buildup.

## 2.7 ADMINISTRATIVE CONSOLE

- A. Description: Microprocessor based VoIP desktop unit, provides for selected, two-way voice communications and signaling with room talkback speakers, intercom stations, as well as between other administrative consoles in the system, along with access to the following system functions.
  - 1. Call Processing
  - 2. All-call or Zoned paging
  - 3. Audio Source Distribution
  - 4. Tone Schedule Distribution
  - 5. Event Scheduling
  - 6. Zone Monitoring
  - 7. System Programming
- B. Features:

1. Keypad: Transmits calls to other stations and initiates commands for programming and operation.
2. Digital Volume Control: Independently regulates incoming-call volume, tones, and program distribution.
3. Tone Annunciation: Momentary audible tone signal announces incoming calls.
4. LED Annunciation: Identifies calling stations, stations in use, room status, and priority levels. LED remains on until call is answered.
5. Speaker Microphone: Transmits intercom voice signals when used via a push to talk switch.
6. Telephone Handset: equipped with retractable cord to allow private conversations.
7. Hard Buttons: To transfer and place calls on hold.
8. Reset Control: Cancels call and resets system for next call.
9. Digital Display: Multi-line alphanumeric LCD readout to register up to four three-digit station numbers and priority level.

## 2.8 CALL STATION

- A. Description: Suitable for initiating normal and emergency priority calls from remote locations to the administration consoles.
- B. Mounting: Flush in a standard single gang outlet box unless otherwise indicated, suitable for mounting conditions indicated.
- C. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
- D. Call Switch: Momentary contact pushbutton signals system that a normal priority call has been placed.
  1. Emergency Priority: Generated by pressing pushbutton multiple times in quick succession or holding down the pushbutton for a programmed time period.
- E. LED Indicator: Status LED confirms active network connection and call placement state or indicates device failure.
- F. System Interface: Supervised connection to room network device, RJ45 connector.
- G. Bypass Control: Temporarily overrides the volume control setting or any status limiting mode when activated by the console or message priority level so that critical messages will be heard at all speaker locations.
- H. Options:
  1. Integral Volume Control: Momentary contact pushbuttons adjust the audio level in the assigned room or zone during audio playback.
  2. Privacy Switch: Prevents transmission of audio signals from the call station to system. When a call is initiated from the call station, the privacy feature is automatically suspended for the duration of the call.
  3. Do Not Disturb Switch: Prevents broadcast of scheduled events, zone pages, and normal priority audio in the assigned room. Emergency and high priority audio as well as manual tones shall override the Do Not Disturb function. When a call is initiated from the

call station, the Do Not Disturb feature is automatically suspended for the duration of the call.

## 2.9 SYSTEM ACCESSORIES

### A. Surge Suppression Devices:

1. AC circuits: UL 1449 listed, 120VAC, 20A branch circuit surge suppressor with EMI filtering. Ditek DTK-120SRD or equal. Shunt type devices are not permitted.
2. DC circuits: UL 497B listed, 24VDC, 5A multi stage hybrid design surge suppressor. Ditek DTK-2MHLP24BWB or equal. Devices using only MOV active elements are not permitted.

### B. Wireguards: Welded steel wire mesh of size and shape for devices requiring protection.

1. Guard design shall not affect performance of device.
2. Factory fabricated and furnished by manufacturer of device.

### C. Punchdown Cabinets: Steel cabinet with standard finish, hinged cover, identification labels, and punchdown blocks for analog circuit termination points.

## 2.10 CONDUCTORS AND CABLES

### A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.

### B. Insulation: Thermoplastic, not less than 1/32 inch thick.

### C. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

### D. Plenum Cable: Listed and labeled for plenum installation.

## PART 3 - EXECUTION

## 3.1 EXAMINATION

### A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

### B. Examine raceway rough-in and electrical connections to verify actual locations of connections before installation.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. All equipment supplied must be specifically listed for its intended use and shall be installed in accordance with the manufacture's recommendations. The contractor shall consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.
- B. Securely fasten all system components to wall and ceiling assemblies using fasteners and supports rated to support the required load in accordance with Section 260500, "Common Work Results for Electrical Systems".
  - 1. Ceiling mounted devices shall not be supported solely by suspended ceilings.
- C. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for installation of conductors and cables.
  - 1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
  - 2. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install cable management.
  - 3. Install plenum cable in environmental air spaces, including plenum ceilings.
- D. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- E. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

### 3.3 PATHWAYS AND CONDUCTORS

- A. Wiring Methods: Install all conductors in metal conduit, minimum 3/4-inch, in accordance with Section 260533, "Raceways and Boxes for Electrical Systems" and manufacturer's recommendations. Conceal raceway, except in unfinished spaces.
  - 1. Unenclosed wiring methods may be used in accessible ceiling spaces.
  - 2. Install plenum rated cable in environmental air spaces, including plenum ceilings.
- B. There shall be no splices in the system other than at device terminal blocks, or on punchdown blocks. "Wire nuts" and crimp splices will not be permitted.
- C. For underground raceways and other wet locations, provide moisture resistant cable.
- D. All communications circuits that extend beyond the building footprint and are run outdoors shall be provided with a surge protective device at both ends.

### 3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553, "Identification for Electrical Systems".
  - 1. Identify all system components, wiring, cabling, and terminals.
  - 2. Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
  - 3. Branch circuit overcurrent protective devices powering any system equipment shall be identified as SCHOOL COMMUNICATIONS CIRCUIT.
  - 4. Install a nameplate on each system equipment to indicate the equipment designation, panelboard and circuit number supplying the equipment.

### 3.5 GROUNDING AND BONDING

- A. Ground audio cable shields only at the power amplifier inputs. Terminate shields at the "floating" end with insulating collars or heat shrink tubing. Preserve continuity of shields at connecting points. Connect all audio grounds in this system to a common point at a rack bonding busbar.
- B. Connect equipment racks to the telecommunication bonding system using listed compression two-hole lugs in accordance with requirements in Section 270526 - Grounding and Bonding for Communications Systems.

### 3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
- B. Schedule tests with at least seven days' advance notice.
- C. Arrange with Owner's representative and other Contractors for period of complete quiet for testing and adjustments to the sound system. Ensure all room finishes are completed prior to testing. Testing may be required to occur after hours.
- D. All test instruments shall be calibrated in accordance with the manufacturer's instructions to ensure measurement accuracy.
- E. Electrical and Mechanical Tests and Inspections:
  - 1. Confirm individual components are installed and performing under provisions of each manufacturer's published specifications.
  - 2. Sound Pressure Level and Acoustic Coverage Test:
    - a. Feed pink noise into system using octaves centered at 500 and 4000 Hz.
    - b. Use sound-level meter to test SPL (in unweighted dB) at three locations in each corridor and assembly space. Two of the test locations shall be at opposite edges of the space, and the third shall be in the middle of the space. Each test location shall consist of two measurements:
      - 1) On-axis, directly underneath the loudspeaker.
      - 2) In the coverage overlap zone halfway between the adjacent loudspeaker.

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- c. Position the measurement microphone at the standing position listening plane.
      - d. Verify the system sound pressure level is distortion free and exceeds the expected ambient noise level by 15 dB.
      - e. Maximum permissible variation in SPL is plus or minus 6 dB.
      - f. Record and report all measured values.
    3. Speech Intelligibility Test: At each test location in the SPL test, use an audio analyzer to measure the speech transmission index (STI) in accordance with IEC 60268-16.
      - a. Verify the system provides a nominal STI value greater than 0.50.
      - b. Record and report all measure values.
  - F. System Acceptance Testing: Provide complete system operational test. Test two-way communications originating from each call station, all-call and any zoned paging, any program sources, and any building system control or supervisory functions. Verify proper routing and volume levels and that system is free of noise and distortion. Comply with test methods in NEMA SB 40 for each system component noted below:
    1. Control Equipment: Verify correct receipt of call inputs, identification of call stations, operation of notification devices and other output functions.
    2. Amplifiers and Annunciation: Verify correct operation, zoning, and any switching.
    3. Secondary Power Supply: Disconnect main power supply and verify secondary power source is sufficient to meet system operational requirements for a minimum of 15 minutes.
    4. Building System Interfaces: Test building system interfaces by operating or simulating the equipment connection. Verify the desired system response.
    5. Peripheral Devices: Test all call switches to verify the signal is routed to the appropriate location and properly identified. Test console key pad functions, microphone and handset voice quality, message waiting, and ringer functionality. Verify speaker audible information.
  - G. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of any paging and independent room speaker-line matching transformers.
  - H. Systems will be considered defective if they do not pass tests and inspections.
  - I. Prepare test and inspection reports indicating test procedures, all measured values, and final device settings.
- 3.7 ADJUSTING
- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- 3.8 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain intercommunication systems.

- B. Training shall consist of not less than eight hours of onsite hands-on instruction for a minimum of four attendees.

END OF SECTION 275123

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## SECTION 283300 - LABORATORY SAFETY SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: Furnish and install a complete and operational Classroom Laboratory Safety Device System where shown on the drawings.
- B. Section Includes:
  - 1. Utility Control Panel
  - 2. Solenoid Valves
  - 3. Electrical Contactors
  - 4. Emergency Shut Off Buttons
  - 5. Flow Switch
  - 6. Accessories

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. PCB: Printed Circuit Board
- B. Definitions
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. Underwriters Laboratories (UL)
    - a. UL 429, "Electrically Operated Valves".
    - b. UL 508A, "Industrial Control Panels".
    - c. UL 61010, "Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use".

#### 1.4 SUBMITTALS

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

B. Shop Drawings: Provide the following

1. Include floor plans, elevations, and sections drawn to scale which show locations of all devices, outlets and equipment. Indicate electrical power connections, approximate location and size of conduit/wiring runs, and other information required to clearly describe the proposed system.
2. Functional Block and Wiring Diagrams: Detail all equipment with wire and connections for power, signal, and control. Clearly differentiate between factory installed wiring and field installed wiring.

C. Closeout Submittals

1. Operation and Maintenance Data: For controller and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
  - a. Routine maintenance requirements for controller and all installed components.

1.5 COORDINATION

- A. Coordinate All work described herein with Division 22, Division 25, and Division 26 requirements.

1.6 WARRANTIES

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace system, controller, components, and accessories that fail in materials or workmanship within 3 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

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

2.2 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by the following:
1. American Gas Safety.
  2. ISIMET.
  3. Lab Automation Control Systems (LACS).
- B. Source Limitations: Obtain each product type through one source from a single manufacturer.

## 2.3 SYSTEM COMPONENTS

### A. Lab Utility Control Panel

1. Comply with UL 61010.
2. Description: Provides instructor independent control over domestic water, and power utilities within the classroom laboratory environment. Include the following features:
  - a. Flush Mounted NEMA 1 enclosure.
  - b. PCB mounted micro controller with outputs for control of contactors and solenoids. Field configurable through onboard DIP switches.
  - c. Terminal blocks for input/output wiring terminations.
  - d. 120VAC Input.
  - e. Two Position Keyed selector switch for panel enable/disable.
  - f. Panel mounted emergency pushbutton.
  - g. Illuminated on/off switches for each utility indicated on drawings (hot/cold water, power)
  - h. Exhaust Fan enable/disable output.
  - i. Built-in programmable timer for utility time out function.

### B. Contactors and Enclosure

1. Comply with UL 60947-4-1.
2. Description: Pre-Assembled enclosure with electrically held contactors to enable/disable power to electrical outlets. Contactors shall open upon loss of power or activation of alarm.
  - a. Provide number of contactors required to disconnect power to outlets indicated on drawings with two spares.
  - b. Contactor coil power provided from control panel.
  - c. NEMA 1 enclosure.

### C. Solenoid Assembly and Enclosure

1. Comply with UL 429.
2. Description: Pre-assembled enclosure with normally closed, general service, zero differential solenoids that close upon loss of power or alarm activation. Reactivation of service requires re-keying at control panel.
  - a. NEMA 1 enclosure.
  - b. Solenoid coil power provided from control panel.
  - c. Suitable for pipe sizes and materials indicated on drawings.
  - d. Listed and approved for use with intended utility services.

### D. Accessories:

1. Remote Pushbutton: Flush wall mounted with stainless steel faceplate and clear flip up protective cover.

## 2.4 SYSTEM SEQUENCE OF OPERATION

- ### A. Factory configure Utility Control Panels to a standard configuration and provide ability to make field adjustments to meet specific project requirements.

- B. Control each cold water, hot water, and power service with independent output circuit at the Utility Control Panel. Do not combine control of utility services onto one output circuit.
- C. Enabling of utility services shall be accomplished through key selector switch at control panel. Individual control of utility services shall then be activated by on/off switches for each utility. Internal time out function shall automatically disable services after programmable time period if key switch is left in the enable position.
- D. System shall be configured so that pressing the emergency button at the control panel or at a remote pushbutton station, will activate the system alarm and all integrated utilities will be disabled and shutdown.
- E. Upon activation of system alarm, control panel shall enable classroom emergency exhaust fan.
- F. Reset of system alarm and shutdown shall be accomplished through a reset of the key selector switch at the control panel.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
  - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install in accordance with manufacturer's recommendations and instructions. Verify manufacturer's mounting heights to comply with ADA requirements.
- B. Where devices interface with other trades, coordinate final location prior to installation and final connections.
- C. Provide control wiring and connections from Utility Control Panel to the following with required conductors plus two spares:
  - 1. Control devices: Minimum 18 AWG, plenum rated cable.
  - 2. Monitoring devices: Minimum 22 AWG, plenum rated cable.

- D. Provide low voltage integration wiring to connection point of mechanical exhaust fan that serves each classroom where a Utility Control Panel is installed. Make connection of wiring and configure to interrupt manual control of the exhaust fans.
- E. Where shown on drawings, provide control wiring from Classroom Utility Control Panel to the Control Panel at the Prep Room. Make connections at panel and terminate at Controller's PC Board so that a panic signal from one unit will place the other into its panic mode. Minimum wiring, 18 AWG, plenum rated cable. Provide cable with six conductors. Final wiring connections shall be as recommended by the manufacturer.

### 3.3 IDENTIFICATION

- A. Comply with Section 260533 "Identification for Electrical Systems"
  - 1. Identify system components, wiring, cabling, and terminals. Identify all fire alarm circuits at terminal and junction locations

### 3.4 FIELD QUALITY CONTROL

- A. Prior to placing the Utility Controller System into service, perform ALL Start-up procedures and Checklists as stated in Manufacturer's Operations and Maintenance Procedure literature
- B. Verify that all components and control devices comply with manufacturer's requirements and recommendations and that all devices and installations conform to Drawings and Specification requirements.
- C. Verify the following:
  - 1. All controlled piping systems have been thoroughly cleaned.
  - 2. All controlled devices and circuits are powered ON
  - 3. Connections to all integrated systems are complete
  - 4. All monitoring systems respond to Alarm.
  - 5. Remote pushbuttons activate the Alarm State
  - 6. Service to emergency showers and eyewashes are not affected by operation of system

### 3.5 CLOSEOUT ACTIVITIES

- A. Demonstration: Review all operating procedures with a representative of the Owner.

END OF SECTION 283300

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## SECTION 284613 - ADDRESSABLE FIRE ALARM SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: This section of the specification includes the furnishing, installation, connection and testing of the microprocessor controlled, intelligent reporting fire detection equipment required to form a complete, operative, coordinated system.
- B. Section Includes:
  - 1. Analog-Addressable fire-alarm system.
  - 2. Fire-alarm control unit (FACU/FACP).
  - 3. Manual fire-alarm boxes.
  - 4. System Detectors.
  - 5. Fire-alarm notification appliances.
  - 6. Fire-alarm annunciators.
  - 7. Fire-alarm addressable interface devices.
  - 8. Fire-alarm system communications.
  - 9. Fire-alarm system accessories.
  - 10. Fire-alarm conductors and cabling.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. DACT: Digital alarm communicator transmitter.
  - 2. FACU (FACP): Fire-alarm control unit (panel).
  - 3. NAC: Notification Appliance Circuit
  - 4. NICET: National Institute for Certification in Engineering Technologies.
  - 5. NRTL: Nationally Recognized Testing Laboratory.
  - 6. SLC: Signaling Line Circuit
- B. Definitions
  - 1. Circuit: Wire path from a group of devices or appliances to a control panel or transponder.
  - 2. Zone: Combination of one or more circuits or devices in a defined building area

- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
  - 1. National Electrical Contractors Association (NECA):
    - a. NECA 305, "Standard for Fire Alarm System Job Practices".

#### 1.4 COORDINATION

- A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

#### 1.5 SUBMITTALS

- A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.
- B. Product Data: For each type of product, including furnished options and accessories.
- C. Shop Drawings: Provide for the fire alarm system.
  - 1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
  - 2. Include floor plans drawn to scale which clearly show locations of devices, equipment. Indicate electrical power connections, approximate location and size of conduit/wiring runs, and other information required to clearly describe the proposed system. Plans should include identification numbers and wiring connections for all equipment and devices in entire fire alarm system.
  - 3. Include enlarged plans, drawn to a scale not less than 1/4 -inch equals 1 foot, for all equipment rooms and any fire command centers with dimensioned equipment layouts.
  - 4. Include detailed riser diagrams based on the project floor plans, with all devices indicated along with proposed circuit routing. The conductor composition for each conduit section shall be provided. Show consecutive connections for all devices with addresses, candela ratings, and speaker wattages.
  - 5. Provide scaled elevations, sections, and details, including critical dimensions and details of attachments to other Work.
  - 6. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
  - 7. Detail assembly and support requirements.
  - 8. Annunciator panel details as required by authorities having jurisdiction.
  - 9. Include current draw for each device submitted and the listed minimum voltage required to operate.
  - 10. Include voltage drop calculations for notification-appliance circuits. Provide maximum allowable voltage drop for panel and for individual NAC circuits.
    - a. Identify Notification Appliance Circuits (NAC) current draws and voltage drops for each circuit. Utilize the "end of line" method for voltage drop calculations and determine worst case voltage at far end of each circuit. In no case shall the



- 
- calculated voltage at any notification appliance fall below the minimum listed operating voltage for the devices used.
- b. Place calculations on a dedicated sheet, for future reference by fire alarm service technicians.
- 11. Include battery-size calculations showing battery capacity and supervisory and alarm standby power requirements.
    - a. Use manufacturer's battery discharge curve to determine expected battery voltage after specified time period of providing standby power.
  - 12. Include system response matrix showing the fire alarm system's actions (outputs) required for each type of alarm, supervisory, and trouble signal. Any non-compliant features must be fully described.
  - 13. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
  - 14. Include performance parameters and installation details for each type of detector.
  - 15. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
  - 16. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
    - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    - b. Provide control wiring diagrams and show equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    - c. Locate detectors in accordance with manufacturer's written instructions.
  - 17. Include equipment rack or console layout, grounding schematic, power calculations, and single-line connection diagram.
  - 18. Include manufacturer's detailed installation instruction for the Fire Alarm Control Panel and all duct mounted smoke detectors, flow switches, tamper switches, supervisory switches, and similar items which require mechanical installation.
- D. Delegated Design: For notification appliances and detectors, in addition to submittals listed herein, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional responsible for their preparation.
- 1. Drawings showing location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of device.
  - 2. Design Calculations: Calculate requirements for selecting spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
  - 3. Indicate audible appliances required to produce square wave signal per NFPA 72.
- E. Qualification Data: For Certified System Designer, Lead Technician, and Installers including names, license numbers, and certifications as described under Quality Assurance.
- F. Sample Warranty.
- G. Field quality-control reports.

H. Closeout Submittals

1. Operation and Maintenance Data: For fire-alarm systems and components to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
  - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
  - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
  - c. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
    - 1) Equipment tested.
    - 2) Frequency of testing of installed components.
    - 3) Frequency of inspection of installed components.
    - 4) Requirements and recommendations related to results of maintenance.
    - 5) Manufacturer's user training manuals.
  - d. Software and Firmware Operational Documentation: Provide operating manuals and backups of software database on USB media. The database provided shall be useable by any authorized and certified distributor of the product line, and shall include all applicable passwords necessary for total and unrestricted use and modification of the database.

1.6 MAINTENANCE MATERIAL

- A. Extra Stock Materials: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
  2. Manual Fire Alarm Boxes: 2% of installed quantity.
  3. Audible and Visual notification appliances: 1% of installed quantity for each type.
  4. Addressable Detectors/Bases: 2% of installed quantity for each type.
  5. Addressable Duct Detectors: 2% of installed quantity.
  6. Addressable Control Relays: 1% of installed quantity.
  7. Monitor Modules (Addressable Interface): 1% of installed quantity.
  8. Isolation Modules/Isolation Bases: 1% of installed quantity.
- B. Keys and Tools: Two extra sets for access to locked or tamper-proofed components.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications
1. Manufacturer must be regularly engaged in manufacture of fire alarm systems of types, sizes, and electrical characteristics required, and whose products are Listed and Labeled.

2. Manufacturer shall maintain an authorized distributor within 100 miles of the project location which stocks a full complement of parts for all equipment to be furnished.

B. Installer Qualifications

1. Obtain certification by NRTL in accordance with NFPA 72.
2. Licensed or certified by authorities having jurisdiction to perform fire alarm installations in the specified jurisdiction.
3. Be in business a minimum of 5 continuous years with documented experience installing fire alarm systems similar in size and scope.
4. Installer must be responsible for all program changes and must be present for all testing and inspections.
5. All connections to the FACP and the system's programming shall only be done by the manufacturer, or by an authorized distributor.

C. Project Personnel Requirements: Installer must have the following certified full-time employees on staff and assigned to the project.

1. All personnel must be trained and certified by manufacturer for installation of units required for this Project.
2. System Designer: Preparation of shop drawings, cabling administration drawings, and field-testing program development by a NICET certified Level IV technician who shall be trained and certified in fire alarm system design by the approved manufacturer within the last 36 months and be licensed by the authorities having jurisdiction.
3. Lead Technician: Minimum NICET certified Level III technician who shall provide all devices, connections, and programming for the fire alarm system. Technician shall be certified by the approved manufacturer within the last 36 months and licensed by the authorities having jurisdiction. The lead technician shall be present at all times when work of this Section is performed at the project site.
4. Installer Qualifications: Any work related to this section shall be installed by personnel trained and certified by the approved manufacturer within the last 24 months.

## 1.8 WARRANTIES

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship for a period of 2 years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to the authority having jurisdiction, and marked for intended location and application.
- B. All components provided shall be listed for use with the selected system.

## 2.2 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. Edwards EST
  - 2. Notifier
  - 3. Siemens
  - 4. Simplex JCI
- B. Being listed as an acceptable Manufacturer in no way relieves obligation of the Contractor to provide all equipment and features in accordance with these specifications.

## 2.3 ADDRESSABLE FIRE ALARM SYSTEM REQUIREMENTS

- A. Noncoded, UL-certified, FM Global-approved, analog/addressable system, with multiplexed signal transmission and voice/strobe evacuation.
- B. The system shall be designed, inspected, tested and approved to provide occupant notification audibility levels of 15 dBA over ambient conditions. Design intelligibility to ensure Common Intelligibility Standard (CIS) rating of 0.7 or Sound Transmission Index of 0.5 in all areas designated on the drawings to have intelligible audio.
- C. Fire Alarm System shall supervise and monitor the integrity of all sub-systems, circuits, and devices connected to the system and annunciate all system faults. All intelligent initiating, signaling, and control devices shall be individually addressed.
- D. The system shall be fully programmable so that any type of input event can be correlated to any combination of output functions.
- E. The fire alarm system operational priority shall ensure that life safety functions takes precedence over other activities coordinated by the system.

## 2.4 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
  - 1. Manual stations.
  - 2. Heat detectors.
  - 3. Smoke detectors.
  - 4. Automatic sprinkler system water flow.
  - 5. Fire-suppression/extinguishing system operation.
- B. Fire-alarm signal must initiate the following actions:
  - 1. Continuously operate alarm notification appliances, including voice evacuation.
  - 2. Identify alarm and specific initiating device at fire-alarm control unit and any remote annunciators. The system alarm LED shall flash and a local distinct audible signal in the control panel shall sound.
  - 3. Transmit an alarm signal to the remote alarm receiving station.
  - 4. Unlock electric door locks in designated egress paths.

5. Release magnetic door holders of designated fire and smoke doors.
  6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
  7. Record events in system memory.
  8. Record events by system printer.
  9. Indicate device in alarm on graphic annunciator.
  10. Switch HVAC equipment controls to fire-alarm mode.
- C. Carbon monoxide alarm signal initiation shall be by one or more of the following devices and systems:
1. Carbon monoxide detector
- D. Carbon monoxide alarm signal must initiate the following actions:
1. Continuously operate alarm notification appliances using a distinctive four-pulse pattern complying with NFPA 720.
  2. Identify alarm and specific initiating device at fire-alarm control unit and any remote annunciators. The system alarm LED shall flash and a local distinct audible signal in the control panel shall sound.
  3. Transmit a carbon monoxide alarm signal to the remote alarm receiving station.
- E. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Control valve tamper supervisory switch.
  2. Duct smoke detectors.
  3. Device tamper.
  4. Zones or individual devices have been disabled.
  5. Elevator shunt-trip control circuit supervision for Shut-Down.
  6. Elevator hoistway detectors for Recall.
  7. Fire pump is running.
  8. Fire pump loss of phase.
  9. Fire pump phase reversal.
  10. Fire pump connected to alternate source.
  11. Fire pump switch/breaker open.
  12. Fire pump controller/system trouble.
  13. Fire-suppression/extinguishing system trouble.
- F. System Supervisory Signal Actions:
1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators. The corresponding system LED shall flash and a local distinct audible signal in the control panel shall sound.
  2. Record the event on system printer.
  3. Transmit a supervisory signal to the remote alarm receiving station with no time delay.
- G. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in circuits.
  2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
  3. Loss of communication with any addressable device or networked panel.
  4. Loss of primary power at fire-alarm control unit.
  5. Ground or a single break in internal circuits of fire-alarm control unit.

6. Abnormal AC voltage at fire-alarm control units.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.
11. Smoke Detector Contamination.

H. System Trouble Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators. The system trouble LED shall flash and a local distinct audible signal in the control panel shall sound.
2. Record the event on system printer.
3. Transmit a trouble to the remote alarm receiving station after a programmable time delay of 200 seconds or as required by AHJ.
4. A trouble signal from loss of primary power shall not be transmitted unless maintained after a programmable time delay of 1 to 3 hours or as required by AHJ.
5. Fire alarm signal shall override trouble signals, but any pre-alarm trouble signal shall reappear when the panel is reset.

2.5 FIRE ALARM CONTROL UNIT (FACU/FACP)

A. General Requirements for Fire Alarm Control Panel:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with NFPA 72 and UL 864, and protected from voltage surges and line transients.
  - a. System software and all control-by-event programs shall be held in nonvolatile memory, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
  - b. Include a real-time clock for time annotation of events on the event recorder and printer. Time-of-Day and date shall be retained through failure of primary and secondary power supplies.
  - c. The Central Processing Unit (CPU) shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the system display by the CPU.
  - d. Provide communication between the FACP and intelligent detectors, addressable modules, local and remote operator terminals, remote circuit interface panels, annunciators, and other system-controlled devices.
  - e. The FACP shall be listed for connection to a central-station signaling system service.
  - f. The system is to have multiple access levels, so owner's authorized personnel can disable individual alarm inputs or normal system responses (outputs) for alarms, without changing the system's executive programming or affecting operation of the rest of the system. A minimum of two different password levels shall be accessible through the display interface assembly to prevent unauthorized system control or programming.

2. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
  3. The system shall perform time-based control functions including automatic changes of specified smoke detector sensitivity settings.
  4. Digitized electronic signals shall employ check digits or multiple polling. In general, a single ground or open on any system signaling line circuit shall not cause system malfunction, loss of operating power, or the ability to report an alarm.
  5. Loss of Power: Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
- B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, three lines of 80 characters, minimum.
  2. Alphanumeric Touch Keypad: Arranged to permit entry and execution of programming, display, and control commands.
  3. Color coded system status LEDs. At minimum, Indicate the status of the following system parameters:
    - a. System AC Power
    - b. System Common Alarm
    - c. System Common Trouble
    - d. System Supervisory
    - e. Signal Silence
  4. Provide operator's interface which allows the following minimum functions. In addition, the operator's interface shall support any other functions required for system control and/or operation:
    - a. Signal Silence Switch: Silenced audible signal shall resound in a time period acceptable to AHJ if the condition has not been resolved.
    - b. System Reset Switch
    - c. System Test Switch
    - d. Panel Silence Switch
    - e. Panel Lamp Test Switch
    - f. System Bypass Switches: Programmable, supervised switches for fire safety function bypasses. i.e. NAC Bypass, Elevator Capture Bypass, HVAC Shutdown Defeat, Smoke Control Bypass, etc. Switch operation shall be password protected.
    - g. Interface shall allow programming of the system without any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.
- C. Notification-Appliance and Signaling-Line Circuits:
1. Signaling Line Circuits (SLC): NFPA, Class A.
    - a. Provide a minimum of one signaling line circuit per floor.
    - b. Locate end of line resistors
  2. Notification Appliance Circuits (NAC): NFPA 72, Class B.
  3. Door Hold Open control circuits: NFPA 72, Class D for fail safe operation.
  4. Size each signaling line circuit and notification appliance circuit to allow a minimum additional capacity of 20%.

D. Signaling Line Circuit (SLC) Modules:

1. Power limited, capable of accommodating up to 198 addressable devices on each SLC and a minimum of 1980 initiating points per system.
2. On-board microprocessor capable of operating in a local mode in the event of a failure in the main CPU of the control panel.
3. Capable of receiving analog information from all intelligent detectors and processing the information to determine whether normal, alarm, or trouble conditions exist for specific detectors.
4. Automatically maintain detector desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. Analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.

E. Notification-Appliance Circuit (NAC) Modules:

1. Power limited, minimum circuit output rating: 2 Amps at 24VDC.
2. Polarized to provide for both synchronized strobes and independent horn/strobe operation over two wires.
3. Selectable as auxiliary power outputs and rated for continuous duty.

F. Digital, Multiplexed Voice/Alarm Signaling: Emergency communication system, integral to FACP, with master and remote microphones, zoned amplifiers, and tone generators that provide both live and pre-recorded messages.

1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the microphones. Amplifiers shall comply with UL 1711. Group speakers into zones as required by building code.
  - a. Allow the application of, and evacuation signal to, multiple zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
  - b. Programmable tone and message sequence selection.
  - c. Provide standard digitally recorded messages for the following:
    - 1) Evacuation
    - 2) All Clear
    - 3) Weather warning
    - 4) Test
    - 5) Stand-by
  - d. Generator tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits.
2. Status Annunciator: Indicate the status of various voice/alarm speaker zones.
3. Amplifiers and tone generators shall automatically transfer to backup units, on primary equipment failure.

G. Serial Interfaces:

1. One USB port for system printer.
2. One USB or Ethernet port for on-site programming or system modification with a PC.



H. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

I. Elevator Recall and Shutdown:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:
  - a. Elevator lobby detectors except the lobby detector on the designated floor.
  - b. Smoke detector in elevator machine room/space or control room/space.
  - c. Smoke detectors in elevator hoist way.
2. Program elevator controller to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Heat Detectors or Water-flow alarm associated with sprinklers in an elevator shaft and elevator machine room shall remove power to elevators associated with the location without time delay.
  - a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

J. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to and powered by fire-alarm system.

K. Remote Smoke-Detector Sensitivity Adjustment and Testing: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out final adjusted values on system printer. The system shall also annunciate a trouble condition when any smoke detector approaches 80% of its alarm threshold due to gradual contamination, with an annunciation of the location of the smoke detector requiring service. If any specialized equipment must be used to program any function of the smoke detector devices, then one must be furnished as part of the system.

L. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station in accordance with parameters specified herein.

M. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands

initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

- N. Primary Power: Obtained from dedicated 120-V ac branch circuit and a high efficiency power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
1. Power supply modules shall have a continuous rating adequate to power all equipment and functions in full alarm continuously. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage. The power supply shall be expandable for additional notification appliance power in 3.0 Ampere increments.
  2. Each system power supply shall be individually supervised.
  3. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating to allow for future system expansion.
  4. Install lock clips on circuit breakers in the "ON" position.
- O. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power shall be automatic and shall not cause transmission of a false alarm.
1. Batteries: Maintenance-free, rechargeable, sealed, lead acid with rated lifespan of 10 years.
  2. Provide sufficient capacity to operate the complete alarm system in normal, supervisory, or trouble conditions, including audible trouble signal devices, mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all components of the system, including all alarm notification devices in alarm mode for a period of 15 minutes. Battery capacity must include a 25% safety factor.
  3. Locate batteries either within the control panel or in a separate substantial steel cabinet, finished on inside and outside with enamel paint. Provide a cylinder lock keyed to match FACP. Separate cells to prevent contact between terminals of adjacent cells and between terminals and other metal parts.
  4. Battery Charger: Provide solid state automatic float type, capable of dual rate charging techniques that will recharge a fully discharged battery to a minimum 70% capacity in 12 hours or less. Locate charger within the control panel or within the battery cabinet. Provide voltmeter and ammeter to indicate battery voltage and charging current.
  5. All standby batteries shall be continuously monitored by the power supply. The power supply shall be able to perform an automatic test of batteries and indicate a trouble condition if the batteries fall outside a predetermined range.
- P. Enclosure: Provide the FACP with a listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators. For convenience, the door may be hinged on either the right or left side (field selectable).
- Q. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe

appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

## 2.6 REMOTE POWER SUPPLIES

- A. Stand-alone panel capable of powering a minimum of four synchronized NACs. Power limited, 24 VDC, filtered-regulated, and supervised. Configurable as a continuous 24VDC auxiliary power output.
- B. Alarms from the host fire alarm control panel shall signal the NAC remote power supply panel to activate. The panel shall monitor itself and each of its NACs for trouble conditions and shall report trouble conditions to the host panel.
- C. Internal Primary and Secondary power supplies: comply with performance requirements for FACP.

## 2.7 MANUAL FIRE ALARM BOXES

- A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
  - 1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type with visual indicator of operation; with screw terminals and integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control panel. When the station is operated, the handle shall lock in a manner showing visual indication of operation.
  - 2. Station Test/Reset: Key-operated test/reset switch. Stations shall be keyed alike with the fire alarm control panel.
  - 3. Manual pull stations that initiate an alarm condition when opening the unit are not acceptable.
  - 4. Indoor Protective Shield: On ALL pull stations, provide factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
  - 5. Weatherproof Protective Shield: At wet locations, provide factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
  - 6. Material: High impact Lexan Polycarbonate or Cast Metal.
  - 7. Suitable for ambient temperatures up to 120 deg F.
  - 8. Where required, provide weatherproof backbox and device listed for outdoor applications.

## 2.8 SYSTEM DETECTORS

- A. General Requirements:
  - 1. Operating Voltage: 24VDC, nominal. Two-wire type.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACP through a SLC.
  3. Device Identification: Detectors shall permanently store an internal identifying type code that the control panel shall use to identify the type of device.
  4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base.
  5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
  6. Integral Visual-Indicating Light: dual LED type. LEDs shall flash under normal conditions, indicating that the device is operational and in regular communication with the control panel. The flashing mode operation of the detector LEDs shall be optional through the system field program.
  7. Automatic Device Mapping: Detector address must be accessible from FACP and must be able to identify detector's location within system and its sensitivity setting.
  8. Detectors shall be rated for operation in the following environment unless noted otherwise:
    - a. Temperature: 32 deg F to 120 deg F
    - b. Humidity: 0-93% relative humidity, non-condensing
  9. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
    - a. Multiple levels of detection sensitivity for each sensor.
    - b. Sensitivity levels based on time of day.
    - c. Automatically compensate for detector sensitivity changes due to ambient conditions and dust build-up within detectors.
  10. Test Means: Provide a test means whereby detectors will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself or initiated remotely on command from the control panel when in the "test" condition.
- B. Photoelectric Smoke Detector: Comply with UL 268.
1. Intelligent photoelectric smoke detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.
  2. Each detector shall utilize an environmental compensation algorithm that shall automatically adjust for background environmental conditions such as dust, temperature, and pressure.
    - a. Provide a maintenance alert signal when 80% of the available compensation range has been used.
    - b. Provide a dirty fault signal when 100% or greater compensation has been used.
  3. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
    - a. Primary status.
    - b. Device type.
    - c. Present average value.
    - d. Present sensitivity selected.
    - e. Sensor compensation range (normal, dirty, etc.).

- C. Duct Smoke Detector: Comply with UL 268A.
  - 1. Listed for air velocity, temperature, and humidity present in specific duct application with standard Intelligent Photoelectric Detector and detector mounting base.
  - 2. Duct Housing Enclosure: NRTL listed for use with supplied detector for smoke detection in HVAC system ducts. Provide gasketed NEMA 4X housing for harsh environments.
  - 3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
  - 4. Relay Fan Shutdown: Fully programmable supervised relay rated to interrupt fan motor-control circuit.
  
- D. Heat Detector: Comply with UL 521.
  - 1. Heat detectors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the control panel, send data to the panel representing the analog level of such thermal measurements.
  - 2. Fixed Temperature Type: Actuated by fixed temperature of 135 deg F unless otherwise required.
  - 3. Combination Type: Actuated by fixed temperature of 135 deg F or rate of rise that exceeds 15 deg F per minute unless otherwise required.
  - 4. Rated for ceiling installation at a minimum of 50 ft centers and suitable for wall mount applications.
  
- E. Multicriteria Detector
  - 1. Multi-criteria optical smoke sensor with integrated rate of rise sensing and optional carbon monoxide detection.
  - 2. Integrated nuisance rejection to reduce unwanted alarms.
  - 3. Provide independent signals to the control panel for detectors with CO sensors.
  
- F. Electro-chemical Carbon Monoxide (CO) Detector: Comply with UL 2075.
  - 1. Initiates a Temporal 4 tone when paired with a sounder base for local audible notification.
  - 2. Transmit a maintenance condition to the control panel when the sensor approaches the end of its useful life.
  - 3. Capable of a functional gas test using a canned test agent to test the functionality of the CO sensing cell.
  
- G. Detector Bases: Suitable for mounting to standard 4-inch octagon or square outlet boxes.
  - 1. Standard Base: Twist lock, suitable for all intelligent detectors. Provided with integral terminal strips for circuit connections, rather than wire pigtails. Capable of supporting a remote alarm indicator light.
  - 2. Relay base: Includes programmable, supervised relay, configurable for control with attached detector or from the FACP. Minimum contact rating of 1 amp at 30VDC and listed for pilot duty.
  - 3. Sounder Base: Includes piezoelectric sounder with configurable low or high output, programmable operation, listed to UL 268. Produces Temporal Code 4 tone for CO detectors and Temporal Code 3 tone for all other detectors. or low frequency 520Hz signal tone patterns.

4. Low Frequency Sounder Base: Emits 520Hz tone as defined by NFPA 72 for sleeping areas, listed to UL 268 and UL 464.
5. Isolator Base: Includes integral isolation module.

## 2.9 NOTIFICATION APPLIANCES

### A. General Requirements

1. Connected to system notification-appliance signal circuits, zoned as noted, equipped for mounting as indicated, and with in and out screw terminals for system connections.
2. All visual appliances shall be synchronized. Light and audible output levels shall be designed to meet ADA and NFPA requirements.
3. Audible/Visual Combination Devices shall comply with all applicable requirements for both Audible Notification and Visible Notification Appliances.
4. Devices located in a damp or wet location shall be listed for environment. Exterior mounted devices shall be provided with a weatherproof backbox.
5. Devices located in sleeping areas shall produce a low frequency alarm signal that has a fundamental frequency of 520Hz +/- 10% and shall be a square wave.
6. Factory finished in color red unless noted otherwise on the drawings.

### B. Fire Alarm Voice-Tone Notification Appliances:

1. Description: Notification appliances capable of outputting voice evacuation messages.
2. Performance Criteria: Comply with UL 1480.
3. Voice-tone appliances shall sound in a three-pulse temporal pattern with a minimum of two cycles preceding and following the voice message, as defined in NFPA 72.
4. Speakers for Voice Notification: Locate speakers for voice notification to provide intelligibility requirements of "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
5. Speaker Operating Voltage: 25V or 70V.
6. Mounting: Flush mount on a standard electrical box.
7. Minimum rated sound pressure level of 84dBA at 10 feet for 1-watt tap.
8. Matching Transformers: Tap range at 1/4-watt, 1/2-watt, 1-watt, and 2-watt, selected to match acoustic environment of speaker location. Speakers shall be tapped at 1 watt for design purposes.

### C. Fire Alarm Visible Notification Appliances: LED strobe lights with clear high impact polycarbonate lens mounted on an aluminum faceplate, complying with UL 1971. The word "FIRE" is engraved in minimum 1-inch- high letters on the housing.

1. Rated Light Output: 15/30/75/110cd or 135/177/185cd, switch selectable at the device. Selected strobe rating shall be visible when the horn-strobe is in its installed position.
2. Voltage: 24VDC nominal
3. Mounting: Wall or ceiling mounted to standard electrical box unless otherwise indicated.
4. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
5. Flashing shall be in a temporal pattern, synchronized with other units. Maximum pulse duration: 2/10ths of one second.
6. Strobe Leads: Factory connected to screw terminals.

- D. Bell: Vibrating under dome type with 10-inch gong, utilize a heavy-duty mechanism, polarized for supervised operation.
  - 1. Voltage: 24VDC nominal.
  - 2. Mounting: Semi-Flush mount on a standard electrical box.

## 2.10 ANNUNCIATORS

- A. Fire Alarm Remote Annunciator
  - 1. Description: Annunciator functions must match those of FACP for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACP, including acknowledging, silencing, resetting, and testing.
  - 2. Mounting: Flush cabinet, NEMA 250, Type 1.
  - 3. Annunciator shall communicate with the fire alarm control panel via a supervised RS-485 communications loop that supports multiple annunciators and shall individually annunciate all zones in the system.
  - 4. Display Type and Functional Performance: Large format LCD Alphanumeric display and LED indicating lights must match those of FACP. Provide manual control switches to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.
  - 5. Power shall be supplied directly from the FACP or listed auxiliary power supply, ensuring a reliable and monitored power source.
  - 6. Provide remote microphone to facilitate live page announcements over the FACP system from the remote annunciator. The remote microphone shall feature a Push-to-Talk switch; local and remote page active LEDs, and a trouble LED.
- B. Fire Alarm Graphic Annunciator Panel: Mounted in aluminum frame with nonglare, minimum 3/16-inch thick, clear acrylic cover over graphic representation of facility. Detector locations must be represented by red LED lamps. Normal system operation must be indicated by lighted, green LED. Trouble and supervisory alarms must be represented by amber LED.
  - 1. Comply with UL 864.
  - 2. Operating voltage must be 24 VDC provided by local battery backed up 24 V power supply provided with annunciator.
  - 3. Include built-in voltage regulation, reverse polarity protection, RS 232/422 serial communications, and lamp test switch.
  - 4. Semi flush mounted in NEMA 250, Type 1 cabinet, with key lock and no exposed screws or hinges.
  - 5. Graphic representation of facility must be CAD drawing and each initiating device must be represented by LED in its actual location. CAD drawing must be at 1:100 scale or larger.
  - 6. LED representing detector must flash two times per second while detector is in alarm.

## 2.11 ADDRESSABLE INTERFACE DEVICES

- A. General Requirements:
  - 1. Arrange to monitor or control one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, pressure, valve tamper, non-addressable devices, and control of building systems.

2. All Circuit Interface Devices shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions.
  3. Equip each module with two (2) diagnostic indicators; a green LED to confirm communications and a red LED to display active status. LEDs shall be visible through the finished cover plate. The module shall be capable of storing a unique serial number and up to 24 diagnostic codes, hours of operation, number of alarms and troubles, and time of last alarm in its memory which can be retrieved for troubleshooting.
  4. Include electronic address-setting means on the module.
- B. Monitor Module: Microelectronic module providing system address for alarm-initiating devices in wired applications with normally open contacts.
1. Supervision: Unless specifically noted otherwise on the drawings provide one monitor module for each sprinkler flow, tamper, and pressure switch.
- C. Control Relay Module: For control of auxiliary devices or equipment.
1. Provide form C dry relay contacts rated 24VDC at 2 amps.
- D. Isolation Module: For short circuit protection on signaling line circuits.
1. When a short circuit is detected, the module isolates the affected segment on the circuit, allowing the remaining devices to continue functioning.
  2. Self-restoring and automatically reconnects to the circuit segment when the fault is removed.
  3. SLC isolation shall be provided for each floor or protection zone of building.

## 2.12 DIGITAL ALARM COMMUNICATIONS

- A. UL 864 listed as conforming to the requirements of NFPA 72 for Central Station connections.
- B. IP/Cellular digital alarm communications transmitter (IP DACT): capable of sending system events to compatible remote central station receivers over a cellular or IP path.
1. UL 864 listed as conforming to the requirements of NFPA 72 for Central Station connections.
  2. TCP/IP Ethernet Communicator supporting encrypted communications.
  3. Cellular Communicator: LTE fall back cellular connection through the cellular module. Provide antenna extension kits where required to ensure a high-quality connection.
- C. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture a transmission line and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If primary service is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of primary line to the remote alarm receiving station over the remaining transmission line. Transmitter shall automatically report transmission channel restoration to the central station. If service is lost on both transmission channels, transmitter shall initiate the local trouble signal.
- D. Digital Data Transmission must include the following at a minimum:
1. Address of alarm-initiating device.
  2. Address of supervisory signal.



3. Address of trouble-initiating device.
4. Loss of ac supply, where exceeding programmable time delay.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Supervised communications.
2. Programmable
3. Auxiliary relay to indicate alarm or trouble.
4. LED display with audible trouble alarm.
5. Manual test report function and manual transmission clear indication.
6. Communications failure with the central station or fire-alarm control unit.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

## 2.13 SYSTEM ACCESSORIES

A. Magnetic Door Holders: wall or floor mounting and complete with matching doorplate. The door portion shall have a plated steel pivot mounted armature with shock absorbing nylon bearing. Material and finish to match door hardware.

1. Operation: Under normal conditions, the magnets shall attract and hold the door open. Upon activation of the building fire alarm system, the devices shall be de-energized, thus releasing the doors on the circuit.
2. Electromagnets: Require no more than 1 W to develop 35-lbf holding force.
3. Wall-Mounted Units: Flush mounted in a single gang electrical box unless otherwise indicated.
4. Rating: 24-V dc operating on power from the fire alarm control panel.
5. Power source shall be supervised.
6. Door hold open magnets shall be furnished with keepers, door chains, and other accessories as required to properly hold open doors as indicated on the Drawings.
7. Operation: Under normal conditions, the magnets shall attract and hold the door open. Upon activation of the building fire alarm system, the devices shall be de-energized, thus releasing the doors on the circuit.

B. Surge Suppression Devices:

1. AC circuits: UL 1449 listed, 120VAC, 20A branch circuit surge suppressor with EMI filtering. Ditek DTK-DF120S1 or equal. Shunt type devices are not permitted.
2. DC circuits: UL 497B listed, 24VDC, 5A multi stage hybrid design surge suppressor. Ditek DTK-2MHLP or equal. Devices using only MOV active elements are not permitted.

C. Wire Guards: Welded steel wire mesh of size and shape for manual stations, detectors, strobes, or other devices requiring protection.

1. Guard design shall not affect performance of device.
2. Factory fabricated and furnished by manufacturer of device.

3. Finish: Paint of color to match the protected device.

- D. Remote Alarm Indicator Lights: Key type switch for testing of the annunciated device.
- E. Terminal Cabinets: Steel cabinet with red finish, hinged lift-a-way cover, barrel key lock, terminal identification labels, and listed terminal blocks for up to 120 high barrier termination points. Terminal block screws shall have pressure wire connectors of the self-lifting or box lug type. Provide "FIRE ALARM TERMINAL CABINET" label in permanent lettering on the enclosure cover
- F. Documentation Cabinet: Steel cabinet with red finish, hinged cover, barrel key lock, key ring hooks for spare keys, and USB storage device for backup documentation. Sized to accommodate standard 8 1/2 by 11 Operation and Maintenance manuals, As-Built Drawings, Completion Documents, and Inspection and Testing Form required by NFPA 72. Provide "SYSTEM RECORD DOCUMENTS" label in permanent lettering on the enclosure cover.

#### 2.14 SYSTEM PRINTER

- A. Dot Matrix printer, listed and labeled as an integral part of fire-alarm system. Tractor feed type that uses ordinary (non-thermal) paper.
- B. The printer shall timestamp such printouts with the current time-of-day and date. The printer shall be standard carriage with 80-characters per line and shall use standard pin-feed paper. Thermal printers are not acceptable. The printer shall operate from a 120 VAC, 60 Hz power source. Provide table and stand for printer.
- C. In the event that the printer is off-line when an event is received, a panel buffer shall retain the data and it shall be printed when the printer is restored to service.

#### 2.15 FIRE ALARM CONDUCTORS AND CABLE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Allied Wiring and Cable
  - 2. Belden
  - 3. Comtran Corporation
  - 4. General Cable
  - 5. Honeywell Genesis
  - 6. Radix Wire & Cable
  - 7. Southwire
  - 8. Superior Essex
  - 9. West Penn Wire
- B. General Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
  - 1. Type FPLR or FPLP, red jacket, suitable for indoor locations.
  - 2. Type PLTC, suitable for underground or wet locations.

3. Twisted, shielded pair, low capacitance, not less than No. 18 AWG unless recommended otherwise by system manufacturer.
4. Circuit Integrity Cable: Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
  1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 EQUIPMENT INSTALLATION

- A. All equipment supplied must be specifically listed for its intended use and shall be installed in accordance with the manufacturer's recommendations. The contractor shall consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.
- B. Comply with NECA 305, NFPA 70, NFPA 72, and requirements of AHJ for installation and testing of fire-alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
  1. Devices placed in service before all other trades have completed cleanup shall be replaced.
  2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- C. Securely fasten all system components to wall and ceiling assemblies using fasteners and supports rated to support the required load in accordance with Section 260500, "Common Work Results for Electrical Systems".
  1. Ceiling mounted devices shall not be supported solely by suspended ceilings.
- D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above finished floor. Locate annunciators at a height that enables easy viewing.

- E. Provide additional remote NAC power supplies as required to comply with voltage drop requirements.
- F. Manual Fire-Alarm Boxes:
  - 1. Install manual fire-alarm boxes in the normal path of egress within 60 inches of the exit doorway.
  - 2. Mount manual fire-alarm box on a background of a contrasting color.
  - 3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- G. Notification Devices:
  - 1. Comply with NFPA 72 and ADA criteria for strobe visual intensity, audible appliance intelligibility, and final device placement.
  - 2. Install wall devices with entire lens between 80-inches and 96-inches above the floor but not less than 6 inches below the ceiling. Install devices on flush-mounted back boxes with the audible device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- H. End of Line (EOL) Resistors: Label devices containing end-of-line resistors with NAC panel and circuit number in such a manner that removal of the device is not required to identify the EOL device. Locate EOL devices in a readily accessible location no more than 12-feet above finished floor.
- I. Smoke and Heat Detectors:
  - 1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
  - 2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
  - 3. Smooth ceiling spacing for smoke detectors shall not exceed 30 feet except in corridors where increased spacing are allowed in accordance with NFPA 72.
  - 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
  - 5. HVAC: Locate detectors not closer than 36 inches from diffusers or return-air openings.
  - 6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
  - 7. When installed in a room, detectors shall be oriented, so their alarm light is visible from the nearest door to the corridor.
  - 8. Unless suitably protected against dust, paint, etc., spot type smoke detectors shall not be installed until the final construction clean-up has been completed. In the event of contamination during construction, the detectors must be replaced by the contractor at no additional cost to the Owner. Covers supplied with smoke detector heads do not provide protection against heavy construction dust, spray painting, etc., and must not be used for that purpose. They are suitable only during final, minor cleanup or touchup operations.
- J. Duct Smoke Detectors:
  - 1. Provide duct smoke detectors for the following locations:
    - a. At all smoke dampers.

- b. At all HVAC units (AHUs, OA units, Heat Pump Units, etc) with fans greater than 2,000 CFM.
  - c. At each story, prior to the duct connection at a common return, for air distribution systems with a combined capacity greater than 15,000 CFM serving more than one story.
  - d. Additional locations required by the Building Code.
2. Comply with NFPA 72, IMC, and NFPA 90A for HVAC unit shutdown and closing of smoke dampers.
3. Install sampling tubes so they extend the full width of duct.
4. Support tubes more than 36 inches long at both ends.
5. Extend the intake tube through the far side of the duct, seal around the tube where it penetrates the duct wall and plug the end with a rubber stopper to facilitate visual inspection and intake tube cleaning.
6. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to final acceptance.
7. Locate duct detectors in a manner that provides suitable, convenient access for required periodic cleaning and calibration.
8. Comply with manufacturer's requirements for clearances from HVAC equipment and duct accessories such as humidifiers.
9. Provide number of detectors per duct in accordance with NFPA 72 requirements based on the size of the air duct, air duct configuration, air speed, and duct manufacturer's installation requirements.
10. Indicate airflow direction on the duct, adjacent to the detector, using stencil or permanent decal.
11. Provide each duct smoke detector with a remote keyed test switch and alarm indicator.

K. HVAC Unit Shutdown

1. Provide control relays for HVAC unit shutdown at the following minimum locations:
  - a. For all fans associated with HVAC units (including fan powered VAVs) connected to an air distribution system with a combined capacity greater than 2,000 CFM. Shut down fans upon activation of the associated smoke detector(s).
  - b. For all High Velocity Low Speed (HVLS) ceiling fans. Shut down fans upon activation of sprinkler system water flow alarm.
2. Comply with NFPA 72, IMC, and NFPA 90A for supervision and control of HVAC unit shutdown components.
3. All shutdown relays shall be directly controlled and monitored by the fire alarm system. Wire relays for fail safe operation.
4. The Building Automation System (BAS) shall not be used for life safety functions unless the BAS is supervised by the Fire Alarm System for off normal conditions.

L. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position and where specifically indicated. Locate at 8'-0" AFF in the nearest corridor or public area and identify with engraved label.

M. Carbon Monoxide Detectors:

1. Ceiling mounted CO detectors should be kept 12-inches from sidewalls.

2. Wall mounted CO detectors should be at least 48-inches above the finished floor, but less than 6-inches from the ceiling.
  3. Locate at least 60-inches from fuel burning appliances.
  4. Install CO detectors no closer than 36 inches from air supply diffusers or return-air openings.
- N. Elevator Hoistway and Machine/Control Rooms and Spaces: Provide initiating devices and elevator controls interface to comply with NFPA 72 and ANSI A17.1 elevator code requirements for elevator recall and shutdown.
1. Coordinate initiating device temperature ratings, sensitivity settings, and location with sprinkler rating and location. Select temperature rating nominal 10 degrees F less than the adjacent fire sprinkler.
  2. Ensure device operating ranges for temperature and humidity are suitable for installed environment. Do not install smoke detectors in unsprinklered elevator hoistway unless required otherwise by AHJ.
- O. Addressable Interface Devices:
1. Addressable interface and control modules (used to monitor all contact type initiating devices) must be in a conditioned space, unless they are tested, listed, and marked for continuous duty across the range of temperatures and humidity expected at their installed location.
  2. Sprinkler system supervisory circuits for monitoring valve position, air pressure, water temperature, pump status, etc., must cause distinct audible and visible indications at the FACP.
  3. Install interface devices used to initiate emergency control functions no more than 36 inches from the component controlling the emergency control function.
- P. Isolation Modules: Provide in the following locations to minimize the impact of wiring faults:
1. After each 50 initiating devices and control points on the addressable loop, or a lesser number where recommended by the manufacturer.
  2. Near the point any addressable circuit extends outside the building, except for those attached to the building exterior walls and well sheltered by walkways.
  3. For loops covering more than one floor, install isolator at terminal cabinet on each floor with additional isolator[s] on any floor with over 50 addresses.
  4. Each isolation module must be clearly labeled, readily accessible for convenient inspection (not above a lay-in ceiling).
- Q. Independent fire-suppression/extinguishing systems
1. Provide interface modules and all control unit connections required to supervise fire-suppression and extinguishing system indicated on drawings.

### 3.3 PATHWAYS AND CONDUCTORS

- A. Wiring Methods: Install all fire alarm wiring in metal conduit, minimum 3/4-inch, in accordance with Section 260533, "Raceways and Boxes for Electrical Systems" and manufacturer's recommendations. Conceal raceway, except in unfinished spaces.
1. Unenclosed wiring methods may be used in accessible ceiling spaces.
  2. Install plenum rated cable in environmental air spaces, including plenum ceilings.

- B. Survivability: Comply with pathway survivability requirements indicated in NFPA 72 and as noted on drawings.
- C. All junction box covers shall be painted red on both sides to designate use for Fire Alarm conductors. The interior of junction boxes shall not be painted.
- D. Where allowed, surface boxes shall be manufactured by the device manufacturer for the installed device, shall match devices in size, and be suitable for finished spaces.
- E. There shall be no splices in the system other than at device terminal blocks, or on terminal blocks in cabinets. "Wire nuts" and crimp splices will not be permitted. All terminal block screws shall have pressure wire connectors of the self-lifting or box lug type.
- F. For underground raceways and other wet locations, provide moisture resistant PLTC cable.
- G. All fire alarm and communications circuits that are run underground or beyond the building footprint shall be provided with a surge protective device at both ends of the circuit.
- H. All circuits leaving the riser on each floor or building zone shall feed through a labeled terminal block in a terminal cabinet accessible from the floor.
- I. T-Taps are not permitted for Class B circuits. Locate end of branch devices in a readily accessible location.
- J. For fire alarm devices in exterior locations, connect raceways to the back or bottom of the device box in a manner that prevents moisture intrusion and build-up.

### 3.4 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
  - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Coordinate connections to electronic access-controlled doors with door hardware specifications and actual door hardware. Provide all connections for release of locking mechanisms in egress paths as required.
- C. Verify exact connection requirements to all equipment and devices of other trades with those trades prior to ordering equipment.
- D. Make addressable connections with a supervised interface device to controlled or monitored devices and systems. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

### 3.5 IDENTIFICATION

- A. Comply with Section 270553, "Identification for Communications Systems"
  - 1. Identify system components, wiring, cabling, and terminals. Identify all fire alarm circuits at terminal and junction locations.
  - 2. Install a nameplate on each fire alarm panel and power supply to indicate the equipment designation, panelboard and circuit number supplying the fire alarm equipment.
  - 3. Branch circuit overcurrent protective devices powering fire alarm equipment shall be identified as FIRE ALARM CIRCUIT with a red and white engraved label permanently affixed to the equipment.
  - 4. Provide engraved label for each remote alarm indicator.
  - 5. Label all addressable control modules to identify their function.
- B. Basic operating instructions shall be framed and permanently mounted at the FACP. (If the owner concurs, they may instead be affixed to the inside of the FACP's door.) In addition, the NFPA 72 "Record of Completion" must either be kept at the FACP, or its location shall be permanently indicated there by an engraved label. All System documentation shall be provided and housed in a Documentation Cabinet at the control panel or other approved location in accordance with NFPA 72.

### 3.6 GROUNDING

- A. Ground FACP and surge protective devices for associated circuits in accordance with Section 260526, "Grounding and Bonding for Electrical Systems".
- B. Ground shielded cables at control panel location only. Insulate shield at device location.

### 3.7 FIELD QUALITY CONTROL

- A. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
- B. Coordinate all testing in occupied buildings with the owner's representative to minimize the disturbance to the building occupants.
- C. Visual Inspections: Conduct prior to testing.
  - 1. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
  - 2. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.
- D. Preliminary Testing
  - 1. Check all wiring for grounds, opens, and shorts, prior to termination at panels and installation of detector heads. The minimum resistance to ground or between any two conductors shall be 10 megohms, as verified with an insulation tester.



2. Ensure all devices and circuits are functioning properly in accordance with manufacturer's requirements.
- E. System Acceptance Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
1. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
  2. Verify candela settings and test visible appliances for public operating mode in accordance with manufacturer's written instructions.
  3. Test all site-specific software functions and provide a detailed report showing the system's operational matrix. Each initiating device shall activate the proper response and system notification.
  4. Verify all other system functions, including (where applicable) elevator capture and the control of HVAC systems, door locks, pressurization fans, fire or smoke doors/dampers/shutters, etc.
  5. Verify digital communicators are on-line and tested for proper communication to the receiving station.
  6. All supervised circuits must also be tested to verify proper supervision.
  7. Verify the voltage drop of each NAC circuit by testing and recording the voltage at the origin and at the EOL for each NAC circuit, under battery power only.
- F. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances, software modification, or wiring modifications. Such re-testing shall be included as part of the base bid and provided at no additional cost to the Owner.
- G. Final Acceptance Test: Complete record drawings and system operation matrix are required prior to scheduling final acceptance test.
1. The owner's representative, monitoring service, and fire department shall be notified before final tests in accordance with local requirements.
  2. Operate every device to verify proper operation and correct annunciation.
  3. Open signaling line circuits and notification appliance circuits in at least two locations to verify proper supervision.
- H. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- I. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72. Submit certified results to the AHJ, Owner, Architect, and Engineer.
- J. Prepare test and inspection reports.
- 3.8 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

- B. The manufacturer's authorized representative must instruct the owner's designated employees in operation of the system, and in all required periodic maintenance. A minimum of 8 hours on-site time will be allocated for this purpose. Two copies of a written, bound summary will be provided, for future reference.
- C. Training shall cover as minimum the following topics:
  - 1. Preventive maintenance service techniques and schedules, including historical data trending of alarm and trouble records.
  - 2. Overall system concepts, capabilities, and functions. Training shall be in depth, so that the owner shall be able to take any device out of service and return any device to service without need of Manufacturer's approval or assistance.
  - 3. Explanation of all control functions, including training to program and operate the system software.
  - 4. Methods and means of troubleshooting and replacement of all field wiring devices.
  - 5. Methods and procedures for troubleshooting the main fire alarm control panel, including field peripheral devices as to programming, bussing systems, internal panel and unit wiring, circuitry and interconnections.
  - 6. Manuals, drawings, and technical documentation. Actual system software used for training shall be provided in digital form and shall be left with the Owner at the completion of training for the Owner's use in the future.
- D. A receipt shall be obtained from the Owner that this has been accomplished, and a copy included in the close-out documents.

END OF SECTION 284613

## SECTION 284800 - TWO WAY EMERGENCY COMMUNICATIONS SYSTEMS FOR RESCUE ASSISTANCE

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: This section includes equipment for providing two-way emergency voice communication for elevator landings or areas of refuge.
- B. Section Includes:
  - 1. Analog elevator landing communications systems.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms
  - 1. ECS: Emergency Communication System.
  - 2. PSTN: Public Switched Telephone Network.
  - 3. UPS: Uninterruptable Power Supply
- B. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
  - 1. Underwriters Laboratories (UL):
    - a. UL 2525, "Standard for Two-Way Emergency Communications Systems for Rescue Assistance".

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Provide the following:
  - 1. Include floor plans drawn to scale which clearly show locations of devices, equipment. Indicate electrical power connections, approximate location and size of conduit/wiring runs, and other information required to clearly describe the proposed system.

2. Include detailed riser diagrams based on the project floor plans, with arrangement of all devices indicated along with proposed circuit routing and interface with fire alarm system.
3. Device wiring diagrams detailing wiring for power, signal and control differentiating clearly between manufacturer installed wiring and field installed wiring.
4. Include battery-size calculations showing battery capacity and standby power requirements.

C. Closeout Submittals

1. Operation and Maintenance Data: For two-way communication system to include in operation and maintenance manuals.
2. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
  - a. Operating instructions laminated and mounted adjacent to master control unit location.

## 1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Five continuous years, minimum, design and manufacture of the materials and equipment specified.
2. Manufacturing facilities certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.
3. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, maintenance, emergency repairs to equipment, and response times less than eight hours.

B. Installer Qualifications:

1. Manufacturer's authorized representative who is trained and certified by the manufacturer for installation, configuration, setup, and programming of the specified product.

## 1.6 WARRANTIES

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace specified product and all its components that fail in materials or workmanship within 3 years from the date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS

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

- B. Comply with UL 2525.

## 2.2 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. Alpha Refuge.
  - 2. Rath.
  - 3. Talk-a-phone.

## 2.3 COMPONENTS

- A. Master Control Unit
  - 1. Flush mounted steel enclosure with hinged door.
  - 2. Integral monitoring panel with LEDs to provide visual indication of the following:
    - a. Activation status of each remote call station.
    - b. Trouble status of each call station pathway.
    - c. Primary and Secondary power supply status.
    - d. Telephone connection status.
  - 3. Handset with a coiled cord and keypad.
  - 4. Audible and Visual sounder/strobe with trouble reset switch.
  - 5. Public Switched Telephone Network (PSTN) Interface:
    - a. The command unit shall be equipped with one (1) PSTN port.
    - b. The PSTN port shall interface through a terminal block.
  - 6. Equipped with analog call station ports to support required number of analog remote call stations.
  - 7. Programmable through the local command unit phone.
  - 8. Primary Power Supply: Obtained from dedicated 120-V ac branch circuit and a high efficiency power-supply module, integral to master control unit, to supply 24-V dc.
  - 9. Secondary Power Supply: 24-V dc supply system integral to master control unit with batteries, automatic battery charger, and automatic transfer switch for operation in the event of primary power source failure. Provide automatic transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power.
    - a. Provide sufficient capacity to operate the complete communication system in normal conditions under quiescent load for a period of 24 hours. Following this period of operation, the battery shall have sufficient capacity to operate the system in emergency condition for a period of 4 hours with all remote call stations activated and all master control stations annunciating the calls. Battery capacity must include a 25% safety factor.
    - b. Locate power supply and batteries within the control panel or in a separate steel cabinet, finished on inside and outside with enamel paint. Provide a cylinder lock keyed to match master control unit. Separate cells to prevent contact between terminals of adjacent cells and between terminals and other metal parts.
- B. Analog Remote Call Station
  - 1. Vandal proof stainless steel with engraved lettering.

2. ADA compliant, flush mounted.
3. "PUSH FOR HELP" button.
4. Red LED indicators to confirm transmission of "Help Requested" signal.
5. Piezoelectric alarm.
6. Hands-free internal speaker and microphone.
7. Dual audio and visual alarms for the hearing and visually impaired.
8. Powered from master control unit unless noted otherwise.
9. Programmable with built in supervised communications and failure relay output.

C. Signage

1. Provide code required tactile signs with raised letter and braille at each remote call station with directions for using the call stations as well as the location of the call station.
2. Comply with ICC/ANSI A117.1, *Accessible and Usable Buildings and Facilities*, requirements for visual characters.

D. Cabling and Conductors: NRTL listed and labeled as complying with NFPA 70, Article 760.

1. Circuit Integrity Cable: Classification CI/CIC, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

## 2.4 SYSTEM OPERATIONAL DESCRIPTION

- A. When in use, the system shall provide two-way audio communications between the Master control station unit, remote call station and/or a call to an off premises supervising station. Communication at the remote call station shall be hands-free after initial contact from the area station. Call out to supervising station shall be a timed occurrence when the master station has not been picked up after a call from a remote station.
- B. When an emergency call is placed by the master unit, it provides the following indications at the area remote call station to assure the caller that the call is being processed. After pressing the "PUSH FOR HELP" call button:
1. Audio and visual confirmation:
    - a. A "HELP REQUESTED" LED shall illuminate.
    - b. An audible alarm shall sound.
- C. The Master control unit allows Emergency Personnel to check status of each remote call station and to talk with each remote call station on an individual basis or all of them together.
- D. A lighted green LED labeled "RESCUE SERVICES" indicates that an emergency is in progress.
- E. If an emergency call is in progress, by lifting the handset on the master control unit you can automatically join the conversation. At this point you can place any or all remote call stations on hold by pushing the hold button corresponding to that unit, which will leave them talking to the called party. Or you can disconnect the called party by pressing the "DISCONNECT TO CALL SERVICES" button, which will leave you talking to the remote area unit.
- F. If there is no emergency call in progress you can call into any or all remote call station by pressing the corresponding talk button to that unit.

- G. By hanging up the master station you disconnect from the conversation while leaving the remote area station continuing any ongoing conversation with the called party.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas for compliance with manufacturer's installation requirements. Confirm installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Comply with Manufacturers installation and programming instructions.
- B. Mount devices plumb and rigid without distortion of boxes. Ensure recessed devices are flush with wall finish and mating with back box.
- C. Locate devices and signage to ensure conformance with building code and ADA requirements.
- D. Wiring Methods: Install wiring in metal conduit, minimum 3/4-inch, in accordance with Section 260533, "Raceways and Boxes for Electrical Systems" and manufacturer's recommendations. Conceal raceway, except in unfinished spaces.
  - 1. Fire Resistance Ratings: Provide 2-hour rated cabling for all circuit pathways between the remote call stations and the master control unit.
- E. Provide communications circuit from nearest telephone DEMARC to master control unit for system PSTN interface.

### 3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553, "Identification for Electrical Systems"
  - 1. Identify system components, wiring, cabling, and terminals.

### 3.4 GROUNDING

- A. Comply with requirements in Section 260526, "Grounding and Bonding for Electrical Systems".
  - 1. Ground shielded cables to a single point at master control unit only. Insulate shield at device location.

### 3.5 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform manufacturer's recommended visual and mechanical inspections and electrical testing.
- C. Functional Testing: After electrical circuitry has been energized, test for compliance with performance requirements:
  - 1. Perform operational tests that include activation of each remote call stations and ensuring proper communication with master control unit.
  - 2. Verify the call out function to the supervising station properly calls out after the set duration.
- D. Acceptance Testing: Perform system acceptance tests required by NFPA 72 and AHJ.
  - 1. Test Fire Alarm supervisory signals in accordance with NFPA 72 and project fire alarm specifications. Verify proper annunciation.
- E. Nonconforming Work:
  - 1. The system will be considered defective if it does not pass tests and inspections.
  - 2. Remove and replace defective units and retest.
- F. Test and Inspection Reports: Prepare a written report to certify compliance with test parameters and record all results.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain two-way communication system.

END OF SECTION 284800



## SECTION 285129 - EMERGENCY RESPONDER COMMUNICATION ENHANCEMENT SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions, Division 01 Specification Sections, and Section 260010 "General Requirements for Electrical Systems" apply to this Section.

#### 1.2 SUMMARY

- A. Description: This performance-based specification section includes labor, material, and equipment to design, furnish, install and test a complete and operating In-Building Emergency Responder Communication Enhancement System for the purpose of amplifying and distributing radio signals in areas of the building with inadequate coverage. The radio signals and frequency bands shall be those in use by the Emergency Responders serving this facility.
- B. Section Includes:
  - 1. Preliminary RF Coverage Assessment.
  - 2. Bi-Directional Amplifier.
  - 3. Battery Back-up Unit.
  - 4. Donor and Distribution Antennas.
  - 5. Annunciator.
  - 6. Passive RF Devices.
  - 7. Cabling.

#### 1.3 REFERENCES

- A. Abbreviations and Acronyms:
  - 1. AHJ: Authority Having Jurisdiction.
  - 2. BDA: Bi-directional amplifier.
  - 3. DAQ: Delivered Audio Quality.
  - 4. DAS: Distributed Antenna System.
  - 5. ERCES: Emergency Responder Communication Enhancement System.
  - 6. FCC: Federal Communications Commission.
  - 7. LMR: Land Mobile Radio.
  - 8. RF: Radio Frequency.
- B. Definitions
  - 1. Backbone (Riser): A communications cable in an in-building ERCES that carries RF signals that are required to make the overall system operational from the donor antenna signal source, through the amplifiers, and up to the connection point of the distribution antenna cables.

2. Critical coverage area: An area designated as critical by the AHJ, such as fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations.
  3. Distribution Antenna Cable (Feeder): A communication cable that carries RF energy in both directions along its length to distribution antennas in one or more places in a building.
  4. Frequency Holder: The entity or the person that's been issued the license to operate those frequencies by the FCC.
- C. Reference Standards: The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest version as of the date of the Contract Documents, unless otherwise specified.
1. Federal Communications Commission (FCC):
    - a. FCC 47 CFR Part 90.219 "Use of Signal Boosters in Private Land Mobile Radio Networks".
  2. Underwriters Laboratories (UL):
    - a. UL 2524, "Standard for In-Building 2-Way Emergency Radio Communications Enhancement Systems".

#### 1.4 COORDINATION

- A. Coordinate system scope and layout requirements, attachment methods, and envelope penetrations with architectural and MEP roof plans, elevations, and sections.
- B. Coordinate installation of equipment supports and roof penetrations with Division 07 Section "Roof Accessories". Do not invalidate roof warranty.

#### 1.5 SEQUENCING

- A. Prior to testing and operating the ERCES, obtain written consent from the AHJ and frequency license holder(s).

#### 1.6 SUBMITTALS

- A. Preliminary RF Coverage Assessment.
- B. Product Data: For each type of product.
- C. Shop Drawings: Provide the following.
  1. Floor plans and ceiling plans showing accurately scaled components and spatial relationship to associated equipment. Include mounting heights with all equipment labels.
  2. Include equipment locations, routing of the distributed antenna system, cabling, antennas, power connections, splitters, couplers, filters, amplifiers, grounding, lightning protection, fire alarm connections, and routing of all cabling.

3. Include building elevation depicting the location of any outdoor antennas associated with the proposed system. Include height of antenna centerline above building, orientation, and location of all external grounding connections and lightning/surge protection.
  4. Include roof attachment and penetration details, coordinated with roof installation warranty.
  5. Include enlarged plan views of Equipment Rooms housing head-end and or other consolidated equipment showing all enclosures required for the system. Indicate emergency power sources, location and circuit requirements both AC power and battery power.
  6. Include uplink and downlink budget calculations.
  7. Include calculations for battery run time.
  8. Wiring Diagrams: Detailed one-line schematic wiring diagrams of the system and the interconnection wiring.
- D. Delegated Design Submittals: Indicate compliance with performance requirements and design criteria listed herein, including analysis data signed and sealed by qualified professional responsible for their preparation.
1. Provide a copy of the AHJ and frequency license holder technical criteria including a list of all channels and frequencies used.
- E. Test Plan. Description of the cable testing procedures, approved by AHJ, to be used including equipment to be used and applicable testing standards.
- F. Test and Inspection Reports
1. Include documentation of all testing procedures and findings.
- G. Qualification Data: For qualified Designer and Installer.
- H. Closeout Submittals
1. In addition to items specified in Division 01 and Section 260010 "General Requirements for Electrical Systems", include the following:
    - a. Final test results.
    - b. Signed product certificates certifying system complies with specified performance requirements.
    - c. FCC License holder approval letter.
    - d. FCC repeater registration documentation.

## 1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Five continuous years, minimum, design and manufacture of the systems specified.
  2. Manufacturing facilities certified to ISO 9001 International Quality Standard with third-party certification verifying quality assurance in design/development, production, installation, and service.
  3. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, maintenance, emergency repairs to equipment, and response times less than eight hours.

B. Installer Qualifications:

1. Manufacturer's authorized representative who is trained and certified by the manufacturer for installation and testing of the specified product.
2. Minimum of five years successful installation experience with Projects of similar size and complexity.
  - a. Upon request, be able to provide a minimum of three reference accounts at which similar work, both in scope and complexity, have been completed by The Contractor within the last three years.
3. Project Personnel Requirements: Installer must have the following certified full-time employees on staff and assigned to the project:
  - a. RF System Designer:
    - 1) Trained and certified in the use of RF design software such as iBwave.
    - 2) NICET IP-PCS Design certification or equivalent experience.
    - 3) Hold a valid FCC issued general radio operator's license.
  - b. Lead Installer:
    - 1) Trained and certified by a nationally recognized organization, school or a certificate issued by the manufacturer of the equipment being installed.
    - 2) NICET IP-PCS Level III certification or equivalent experience.
    - 3) Hold a valid FCC issued general radio operator's license.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer instructions for storage and handling of coaxial cable to prevent damage to the cable.

1.9 WARRANTIES

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace specified product, and all of its components that fail in materials or workmanship within 12 months from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended use.
- B. ERCES Active Components: Comply with UL 2524.
- C. All equipment shall have required FCC approvals.
- D. Enclosures: Provide NEMA 4 or 4X rated enclosures for all ERCES equipment per NFPA requirements. NEMA 3R rated enclosures may be used for battery systems that require venting. All enclosures shall be red in color.

## 2.2 SYSTEM PERFORMANCE REQUIREMENTS

### A. Delegated Design Criteria:

1. Coordinate with the AHJ to ascertain operating frequencies in use. Include local fire, police, EMS, Sheriff and any state, city or county first responder frequencies as required by the AHJ.
2. Provide equipment compatible with the existing state, county and local Fire/Police communications system utilized by the Public Safety and Emergency Responder agencies.
3. Fully coordinate with all agencies involved and any state, federal or county agencies required and fully comply with requirements of such agencies.
4. Provide a distributed antenna system to provide in-building amplification for all in-use bandwidths tuned to the frequencies utilized.
5. Comply with Frequency License Holder technical criteria.
6. Comply with applicable federal regulations outlined in FCC 47 CFR 90.
7. Provide a system that does not raise the noise floor at the public safety communications site closest to the ERCES or any other receiving site within the public safety communication network.
8. Provide a system that does not generate nor is susceptible to any harmful electromagnetic emission, radiation, or induction that degrades, obstructs, or interrupts the operation of the installed system, any computer system, or other building system.
9. Coverage: Provide a system that achieves sufficient signal coverage in 95 percent of all areas on each floor and 99 percent of all critical areas of the building.
10. Signal Strength: Provide a signal strength sufficient to produce usable voice communications throughout the coverage area as defined by the fire code official.
11. Maintain isolation between the donor antenna and all distribution antennas to a minimum of 20 dB above system gain.
12. Design and install the system per NFPA, Building Code, Fire Code, and FCC requirements.
13. Optional methods of achieving conformance to the code and distributing the signal throughout the building may be submitted for consideration.

## 2.3 MANUFACTURERS

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

1. ADRF.
2. Bird Technologies.
3. Comba.
4. Commscope/Andrew.
5. Comprod.
6. Corning.
7. Dali.
8. Fractal Antenna Systems.
9. Laird Antenna.
10. Motorola.
11. Nextivity.
12. RFS.

13. Times Microwave.
14. Westell.

- B. Source Limitations: Obtain components through one source who assumes responsibility for system component compatibility.

## 2.4 SYSTEM COMPONENTS

- A. Bi-Directional Amplifier: Channelized Digital Single/Dual Band, Class A operation with frequency band(s) selected to match the local municipality public safety radio system(s).
1. Gain: Independently adjustable for both downlink and uplink amplification, selected to meet system performance criteria.
  2. Provide BDA with the following features:
    - a. Automatic Gain Control (AGC).
    - b. Automatic Level Control (ALC).
    - c. Oscillation detection and control circuitry.
    - d. DSP Programmable RF filters.
    - e. Firmware/software upgradeable band migration.
    - f. Dry contacts for system monitoring.
    - g. Wall mount enclosure.
  3. Integral power supply with built-in battery charging.
    - a. Primary power source: Hardwire to dedicated 120V, 20A branch circuit from lockable circuit breaker. Connect to emergency branch of standby generator where available.
- B. Battery Backup Unit:
1. Secondary power source: Dedicated batteries and enclosure, capable of operating the system for at least 12 hours at 100% operation capacity.
  2. Include self/automatic charging system.
  3. Batteries: Marked with month and year of manufacture.
- C. Remote Annunciator: Located in fire control room or other public location to annunciate to status of all signal booster locations.
1. Provide visual and optional audible annunciation of code required alarms.
  2. Powered from Battery Backup Unit.
  3. Low profile housing, wall mounted to standard electrical box.
- D. Emergency Power Off Switch: Normally open switch suitable for manually turning on/off the amplifier via interface with BDA. Provide with guard to prevent inadvertent operation.
- E. Antennas:
1. Donor Antenna: Type, frequency band, and azimuth pattern selected to meet system performance criteria.
    - a. Donor Antenna Mast: Galvanized steel, wind rated per AASHTO Wind Charts with an additional 10 mph rating and a 1.3 gust factor. Include all required supports, mounting hardware, and anchoring required for components per manufacturer's requirements.

2. Distribution Antennas: Ceiling mount, low profile, with patterns selected to meet system performance criteria.
- F. Passive RF Devices: Splitters, combiners, couplers, tappers, and attenuators.
1. Selected to meet system performance criteria.
  2. Low insertion loss.
  3. Connector Style: Compatible with system components.
  4. Ingress Rating: IP65.
- G. Cabling, Connectors, and Supports:
1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard, UL 444 or UL 1655, and NFPA 70 for the following types:
    - a. Plenum Applications: Type CMP/CATVP complying with NFPA 262.
    - b. Non-plenum applications: Type CMR/CATVR complying with UL 1666.
    - c. Wet Location and Outdoor Applications: UV and moisture resistant OSP.
  2. Backbone and Distribution Cable: 50-ohm, ½-inch low loss coaxial cable with copper clad aluminum inner conductor and continuous corrugated copper outer conductor.
  3. Antenna Jumper Cable: 50-ohm, ½-inch super flexible pre-terminated coaxial cable assemblies.
  4. Connectors: N-type or 4.3-10 mini DIN type threaded RF connectors.
  5. Hangers and Straps: Designed and approved for use with associated cables.
  6. Fiber Optic Cable and Connectors: Comply with Section 271300, "Communications Backbone Cabling"
  7. Ensure any stop-bands built into the cable do not block the frequencies used.
  8. Unless specified or approved by the Engineer, radiating coaxial cable is not permitted.

## PART 3 - EXECUTION

### 3.1 PRELIMINARY RF COVERAGE ASSESSMENT

- A. After the area of Work is permanently enclosed with all windows, doors, wall finishes, and roofing in place, perform an indoor and outdoor coverage assessment to determine if an ERCES is required.
1. Utilize the grid testing methodology described in the Field Quality Control section to evaluate signal coverage in general and critical areas.
- B. Submit results of assessment to Architect and Engineer for review.

### 3.2 PREPERATION

- A. Before testing, verify and coordinate the following with the AHJ:
1. Document all frequencies used by emergency responders within the jurisdiction.
  2. Document use of receiver base stations, repeaters or boosters in the first responder radio system, and if so, where they are located.

3. Determine requirements for AHJ representation and involvement during testing. If representation is required either on-site or at receiver base station, costs involved shall be included in the Bid.
4. Coordination with municipalities and the receiver base stations.
5. Confirm if AHJ will waive radio coverage per building code and fire code exceptions.

B. Certificates and Authorizations

1. Provide certificate of authority and/or operational authority from the frequency holder of all individual services utilizing this System. Include the FCC station identification information, details of frequency, power, and modulation, and a specific authority to operate a distribution and/or rebroadcast system on said frequency at the project location, any restrictions in operating conditions, levels, emissions or other conditions, and issued in the name of the facility with a point of contact at the Licensee.

3.3 EXAMINATION

- A. Examine areas for compliance with manufacturer's installation requirements. Confirm installation tolerances and other conditions affecting performance.
- B. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 INSTALLATION

- A. Wiring Methods: Install all cabling in accordance with manufacturer's recommendations. Conceal cabling, except in unfinished spaces.
  1. Fire Resistance Ratings:
    - a. Provide 2 hour rated enclosure or area for backbone cables and backbone cable components.
    - b. Provide survivability level 1 or 2 for distribution cables per NFPA requirements.
  2. Where backbone and distribution cable are subject to physical damage or where cabling is installed exposed in finished areas, provide raceway in accordance with Section 260533, "Raceways and Boxes for Electrical Systems" and Section 270528, "Pathways for Communications Systems".
  3. Provide independent supports and secure cabling using approved hangers and straps at a maximum of 48-inches in accordance with Section 270528, "Pathways for Communications Systems".
  4. Provide roof raceway penetrations for donor antenna cables with appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations to ensure compatibility with the roofing specifications and warranty.



- B. Mount all active components on equipment racks or walls in readily accessible location acceptable to AHJ. Secure in place, plumb, square, and level. Mount wall mounted equipment over a 1/2-inch fire rated plywood, securely attached to the wall.
- C. Provide a dedicated annunciator remote from the ERCES equipment at an approved location.
- D. Antenna Installation:
  - 1. Install antennas in accordance with manufacturer's instructions.
  - 2. Donor Antenna:
    - a. Locate antenna and mast to comply with system performance criteria.
    - b. Affix antenna mast to rigid building structure, plumb and level, in a manner that does not invalidate roofing system warranty.
    - c. Permanently affix donor antenna to mast using manufacturer's recommended hardware. Do not co-locate donor antenna with any other system antenna.
    - d. Seal exposed donor antenna cable connections from moisture using butyl rubber wrap and UV resistant PVC tape.
  - 3. Interior Distribution Antennas:
    - a. Install interior antennas centered and in-line with other ceiling mounted devices.
- E. Cable Installation:
  - 1. Handle and install cabling without kinks, sharp bends or deformations or abrasions as recommended by the cable manufacturer to comply with bend radius requirements.
  - 2. Comply with manufacturer's installation requirements for pulling and securing cable. Only utilize hangers and clamps approved for use with associated cable.
  - 3. Utilize cable manufacturers stripping and crimping tools.
  - 4. Properly support all cables with dedicated hangers or brackets.
- F. Separation from other systems:
  - 1. Install antennas and cabling a minimum of 24" from any EMI producing source. Coordinate routing with field conditions and other trades.
- G. Fire Alarm Monitoring:
  - 1. Provide interface with fire alarm system to monitor signal source and system integrity in accordance with Fire Code, NFPA 1225, NFPA 72 and Section 284613, "Addressable Fire Alarm Systems".
  - 2. Report system malfunctions as supervisory signals in accordance with NFPA requirements.
  - 3. Where approved by the building code official, a single supervisory interface may be used.
- H. Survey facility for any other RF producing components such as mobile radio or base stations and maintain proper separation of antennas to not cause interference. Perform adjustments to power output or antenna locations as required to mitigate interference. Coordinate any required system adjustments with Owner's representative.

- I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- J. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, use a calibrated torque tool to achieve that indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

### 3.5 GROUNDING AND BONDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" and Section 270526 "Grounding and Bonding for Communications Systems".
  - 1. Ground cable shields and equipment per manufacturer's requirements.
  - 2. Provide antenna discharge units and surge protection for donor antenna coaxial cabling in accordance with NEC requirements. Locate as close to building penetration as possible.
  - 3. Ground antenna, antenna mast, and discharge units in accordance with NEC and manufacturer's requirements.

### 3.6 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems".
  - 1. Identify all interior antennas to coincide with schematic diagram inside BDA.
  - 2. Identify all exterior RF Antenna cables outside and inside at their point of entry.
  - 3. Identify all cabling at regular intervals but not less than 50ft with identifiers reading "Public Safety Radio".
  - 4. Permanently affix schematics of the system within the main BDA enclosure.
  - 5. Affix FCC information as to the license holder, call letters, frequencies in use and other pertinent information on the exterior of the BDA along with the system integrator contact information.

### 3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
- B. Provide written 7-day advance notice of any testing to allow The Engineer and Owner's Representative the option to witness the tests.
- C. Visual and Mechanical Inspections:
  - 1. Inspect connectors for correct pin depth, torque, and weatherproofing.
  - 2. Inspect cables for damage from inadequate bending radius, crushing, or deformation.
  - 3. Verify mechanical protection has been provided where cables are subject to physical damage.
  - 4. Confirm labels for donor antenna(s) physical location(s), cable type and cable length.

5. Ensure all cables are securely captivated with an approved clamp or strap and that the outer jacket has not been compromised from over tightening.
6. Verify all interior antennas have an identifying number visible from the traffic path location.
7. Verify equipment enclosure ratings and check for proper ventilation.
8. Verify that the antenna(s), BDA(s), and applicable power supplies are installed to standards and are provided with appropriate working clearances.

D. System Startup Testing:

1. Confirm proper donor antenna orientation via signal strength test. Coordinate with system municipality for the closest and/or strongest tower/signal source to determine orientation.
2. Sweep donor antenna(s) using a calibrated FTDR for Return Loss and Distance to Fault.
3. Measure and record donor antenna grounding hardware and ground resistance for adherence to manufacturer or R56 specifications utilizing a megger documenting reading(s) and exact location(s).
4. Measure and record received signal strength of all applicable frequencies at input.
5. Verify BDA amplified power output with spectrum analyzer in both directions from RF in/out.
6. Test amplifiers for proper gain output and signal level.
7. Check spectral purity of amplified signal for harmonics, spurs and distortion in both directions.
8. Perform an over the air sweep test for excessive harmonic content, spurs and distortion.
9. Sweep entire cable plant of each frequency band utilizing a FTDR for Return Loss and Distance to Fault from BDA out to building.
10. Cabling and connectors shall be tested with a FTDR Meter for continuity and signal levels for RF power. Testing shall be for input and output paths.
11. Check and log AC input voltages and document circuit number, breaker and physical location for both the BDA and AC/DC supply.
12. Test battery output under load for 1 hour for proper output. Test charging circuitry for proper performance.

E. Acceptance Tests

1. Utilize a grid testing procedure to test all the radio frequencies used by the ER for sufficient coverage, signal quality, and signal strength.
  - a. Divide each floor area into a grid of 20 equal test areas.
  - b. Test each grid area for signal quality and signal strength using test methods described below.
  - c. Perform measurements starting in the center of each test grid. Moving in a pre-defined "X" pattern, obtain sample values to create a statistical average for the test area.
  - d. Repeat testing methodology for each grid area.
2. RF Signal Strength Testing
  - a. The signal strength test shall be conducted using a calibrated (within last 12 months) spectrum analyzer utilizing antennas similar to those used by the emergency responders.
  - b. Where signal strength out of the building cannot be efficiently measured, a DAQ Test shall be conducted using a calibrated portable radio of the latest brand and

- 
- model used by the agency talking through the agency's radio communications system.
- c. Each floor of the building shall be divided into a grid of 20 approximately equal test areas.
  - d. A test location approximately in the center of each test area shall be selected for the test, with the radio enabled to verify two-way communications to and from the outside of the building through the public agency's radio communications system. Once the test location has been selected, that location shall represent the entire test area. Failure in the selected test location shall be considered failure of that test area. Additional test locations shall not be permitted.
  - e. Measurements shall be made with the antenna held in a vertical position at three (3) to four (4) feet above the floor to simulate portable radios worn on the belt or turnout coat pocket.
  - f. A maximum of one (1) (or 5 percent) of nonadjacent test areas shall be allowed to fail the test per floor.
  - g. In the event that two or more (or > 5 percent) of the test areas fail the test, in order to be more statistically accurate, the floor shall be permitted to be divided into 40 equal test areas. Failure of more than two (or 5 percent) nonadjacent test areas shall result in failure of the test. If the building fails the 40 area test, the building shall be deemed in non-conformance to Code. The facility shall be equipped with an in-building RF amplification antenna system to meet a 90 percent coverage requirement per floor and retested.
  - h. The gain values of all amplifiers shall be measured and the test measurement results shall be kept on file with the building Owner so that the measurements can be verified during annual tests.
3. Voice Signal Quality Testing
    - a. For quality purposes, DAQ readings shall be taken at the same time as the above RF signal strength measurements. The DAQ scale is as follows:
      - 1) DAQ 1: Unusable. Speech present but not understandable.
      - 2) DAQ 2: Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.
      - 3) DAQ 3: Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.
      - 4) DAQ 3.4: Speech understandable without repetition. Some noise or distortion present.
      - 5) DAQ 4: Speech easily understandable; little noise or distortion.
      - 6) DAQ 4.5: Speech easily understandable; rare noise or distortion.
      - 7) DAQ 5: Perfect; no distortion or noise discernible
    - b. A DAQ level of 3 or better throughout the building shall be deemed acceptable and passing. Areas not achieving this level shall be deemed as failing.
  4. Test Fire Alarm Supervisory Signals in accordance with NFPA 72 and project fire alarm specifications. Verify proper annunciation.
- F. Test and Inspection Reports: Prepare a written report to certify compliance with test parameters and record the following:
1. Test procedures used.
  2. Date, time, and weather conditions during testing.
  3. Results that comply with requirements.

- 4. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- 5. Prepare information in a format required by the AHJ.
- G. Products will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.
- H. Permission to operate any ERCES system should be provided in writing.

### 3.8 ADJUSTING

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

### 3.9 DEMONSTRATION

- A. Provide 4 hours of system training and maintenance instruction to Owner's personnel.

END OF SECTION 285129

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## SECTION 31 10 00 - SITE CLEARING

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Clearing and protection of vegetation.
- B. Removal of existing debris.

#### 1.02 RELATED SECTIONS

- A. Section 01 11 00 - Summary: Limitations on Contractor's use of site and premises.
- B. Section 01 11 00 - Summary: Sequencing and staging requirements.
- C. Section 31 25 00 - Temporary Erosion and Sedimentation Control.
- D. Section 01 73 00 - Execution: Project conditions; protection of bench marks, survey control points, and existing construction to remain; reinstallation of removed products.
- E. Section 31 22 00 - Grading: Topsoil removal.
- F. Section 31 22 00 - Grading: Fill material for filling holes, pits, and excavations generated as a result of removal operations.
- G. Section 31 23 23 - Fill and Backfill: Fill material for filling holes, pits, and excavations generated as a result of removal operations.
- H. Section 31 23 23 - Fill and Backfill: Filling holes, pits, and excavations generated as a result of removal operations.

#### 1.03 REFERENCES

#### 1.04 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.
- B. Erosion Control Plan: Showing:
  - 1. Vegetation removal limits.
  - 2. Areas for temporary construction and field offices.

#### 1.05 QUALITY ASSURANCE

- A. Clearing Firm: Company specializing in the type of work required.
  - 1. Minimum of five years of documented experience.

#### 1.06 PROJECT CONDITIONS

- A. Minimize production of dust due to clearing operations; do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.

- B. Comply with other requirements specified in Section 01 73 00.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

- A. Fill Material: As specified in Section 31 22 00 – Grading

## PART 3 - EXECUTION

### 3.01 EXISTING UTILITIES AND BUILT ELEMENTS

- A. Coordinate work with utility companies; notify before starting work and comply with their requirements; obtain required permits.
- B. Protect existing utilities to remain from damage.
- C. Do not disrupt public utilities without permit from authority having jurisdiction.
- D. Protect existing structures and other elements that are not to be removed.

### 3.02 VEGETATION

- A. Scope: Remove trees, shrubs, brush, and stumps in areas to be covered by building structure, paving, playing fields, lawns, and planting beds.
- B. Do not begin clearing until vegetation to be relocated has been removed.
- C. Do not remove or damage vegetation beyond the following limits:
  - 1. 40 feet (12 m) outside the building perimeter.
  - 2. 10 feet (3.1 m) each side of surface walkways, patios, surface parking, and utility lines less than 12 inches (305 mm) in diameter.
  - 3. 15 feet (4.6 m) each side of roadway curbs and main utility trenches.
  - 4. 25 feet (7.5 m) outside perimeter of pervious paving areas that must not be compacted by construction traffic.
  - 5. Exception: Specific trees and vegetation indicated on drawings to be removed.
  - 6. Exception: Selective thinning of undergrowth specified elsewhere.
- D. Install substantial, highly visible fences at least 3 feet (1 m) high to prevent inadvertent damage to vegetation to remain:
  - 1. At vegetation removal limits.
  - 2. Around trees to remain within vegetation removal limits; locate no closer to tree than at the drip line.
  - 3. Around other vegetation to remain within vegetation removal limits.
  - 4. See Section 01 50 00 for fence construction requirements.
- E. In areas where vegetation must be removed but no construction will occur other than pervious paving, remove vegetation with minimum disturbance of the subsoil.
- F. Vegetation Removed: Do not burn, bury, landfill, or leave on site, except as indicated.
  - 1. Chip, grind, crush, or shred vegetation for mulching, composting, or other purposes;



- preference should be given to on-site uses.
2. Trees: Sell if marketable; if not, treat as specified for other vegetation removed; remove stumps and roots to depth of 18 inches (450 mm).
  3. Existing Stumps: Treat as specified for other vegetation removed; remove stumps and roots to depth of 18 inches (450 mm).
  4. Sod: Re-use on site if possible; otherwise sell if marketable, and if not, treat as specified for other vegetation removed.
  5. Fill holes left by removal of stumps and roots, using suitable fill material, with top surface neat in appearance and smooth enough not to constitute a hazard to pedestrians.
- G. Dead Wood: Remove all dead trees (standing or down), limbs, and dry brush on entire site; treat as specified for vegetation removed.
- H. Restoration: If vegetation outside removal limits or within specified protective fences is damaged or destroyed due to subsequent construction operations, replace at no cost to Owner.

### 3.03 DEBRIS

- A. Remove debris, junk, and trash from site.
- B. Leave site in clean condition, ready for subsequent work.
- C. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION 31 10 00

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## SECTION 31 22 00 - GRADING

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Removal of topsoil.
- B. Rough grading and preparation of site for site structures, building pads, and drainage features.
- C. Finish grading.

#### 1.02 RELATED SECTIONS

- A. Section 31 10 00 - Site Clearing.
- B. Section 31 23 00 - Excavation.
- C. Section 31 23 23 - Fill and Backfill: Filling and compaction.
- D. Section 31 23 33 - Trenching for Site Utilities: Trenching and backfilling for utilities.
- E. Section 32 92 19 - Seeding: Finish ground cover.
- F. Section 32 92 23 - Sodding: Finish ground cover.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for general requirements relating to unit prices for this work.
- B. Topsoil: Applies to Unit Price.
  - 1. Measurement Method: By the square yard down to a drawing-defined elevation.
  - 2. Includes: Excavating existing topsoil, stockpiling, scarifying substrate surface, placing where required, and compacting.

#### 1.04 SUBMITTALS

- A. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

#### 1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with State of North Carolina, Highway Department standards.
  - 1. Maintain one copy on site.

#### 1.06 PROJECT CONDITIONS

- A. Protect above- and below-grade utilities that remain.
- B. Protect plants, lawns, rock outcroppings, and other features to remain as a portion of final landscaping.
- C. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from grading equipment and vehicular traffic.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS

- A. Fill Materials: See Section 31 23 23.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Verify that survey bench mark and intended elevations for the Work are as indicated.

#### 3.02 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Stake and flag locations of known utilities.
- C. Locate, identify, and protect utilities that remain, from damage.
- D. Notify utility company to remove and relocate utilities.

#### 3.03 ROUGH GRADING

- A. Remove topsoil from areas to be further excavated, re-landscaped, or re-graded, without mixing with foreign materials.
- B. Do not remove topsoil when wet.
- C. Remove subsoil from areas to be further excavated, re-landscaped, or re-graded.
- D. Do not remove wet subsoil, unless it is subsequently processed to obtain optimum moisture content.
- E. When excavating through roots, perform work by hand and cut roots with sharp axe.
- F. See Section 31 23 23 for filling procedures.
- G. Benching Slopes: Horizontally bench existing slopes greater than 1:4 to key fill material to slope for firm bearing.
- H. Stability: Replace damaged or displaced subsoil to same requirements as for specified fill.

#### 3.04 SOIL REMOVAL

- A. Stockpile excavated topsoil on site.
- B. Stockpile topsoil to be re-used on site; remove remainder from site.
- C. Remove excavated topsoil from site.
- D. Stockpile excavated subsoil on site.
- E. Stockpile subsoil to be re-used on site; remove remainder from site.
- F. Remove excavated subsoil from site.
- G. Stockpiles: Use areas designated on site; pile depth not to exceed 8 feet (2.5 m); protect from erosion.

#### 3.05 FINISH GRADING

- A. Before Finish Grading:
  - 1. Verify building and trench backfilling have been inspected.
  - 2. Verify subgrade has been contoured and compacted.
- B. Remove debris, roots, branches, stones, in excess of 1/2 inch (13 mm) in size. Remove soil contaminated with petroleum products.
- C. Where topsoil is to be placed, scarify surface to depth of 3 inches (75 mm).
- D. In areas where vehicles or equipment have compacted soil, scarify surface to depth of 3 inches (75 mm).
- E. Place topsoil in areas where seeding are indicated.

- F. Place topsoil where required to level finish grade.
- G. Place topsoil to the following compacted thicknesses:
  - 1. Areas to be Seeded with Grass: 6 inches (150 mm).
  - 2. Areas to be Sodded: 4 inches (100 mm).
  - 3. Shrub Beds: 18 inches (450 mm).
  - 4. Flower Beds: 12 inches (300 mm).
  - 5. Planter Boxes: To within 3 inches (75 mm) of box rim.
- H. Place topsoil during dry weather.
- I. Remove roots, weeds, rocks, and foreign material while spreading.
- J. Near plants spread topsoil manually to prevent damage.
- K. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of subgrade.
- L. Lightly compact placed topsoil.

### 3.06 TOLERANCES

- A. Top Surface of Subgrade: Plus or minus 1/10 foot (30 mm) from required elevation.
- B. Top Surface of Finish Grade: Plus or minus 1/2 inch (13 mm).

### 3.07 FIELD QUALITY CONTROL

- A. See Section 31 23 23 for compaction density testing.

### 3.08 CLEANING AND PROTECTION

- A. Remove unused stockpiled topsoil and subsoil. Grade stockpile area to prevent standing water.
- B. Leave site clean and raked, ready to receive landscaping.

END OF SECTION 31 22 00

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## SECTION 31 22 16 - SUBGRADE AND ROADBED

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. The Drawings and provisions of the General Conditions, Supplemental Conditions, and Division 1 are included as part of this Section as though bound herein.
- B. Section 500 of the North Carolina Department of Transportation "Standard Specifications for Roads and Structures" dated July 2006.

#### 1.02 WORK INCLUDED

- A. The work covered by this section consists of the preparation, shaping, and compaction of that portion of the roadway areas that are to be paved.

### PART 2 - PRODUCTS

Not Used.

### PART 3 - EXECUTION

#### 3.01 CONSTRUCTION METHODS

- A. Preparation of Subgrade:
  - 1. The subgrade shall be shaped to the lines, grades, spot elevations and typical sections shown on the plans. Where the Owner's Representative directs that areas of the subgrade are to be stabilized, the subgrade in such areas may be left uniformly below grade to provide for the addition of the stabilizer material.
  - 2. All unsuitable material, boulders, and all vegetative matter shall be removed and replaced with suitable material. Suitable material, when not available from the subgrade work, shall be taken from pond excavation or borrow sources.
  - 3. Material excavated in preparing the subgrade shall be stored or stockpiled in such a manner as to not interfere with proper drainage or any of the subsequent operations of placing aggregate base course.
- B. Compaction of Subgrade:
  - 1. When tested, all material to a depth of 12 inches below the finished surface of the subgrade shall be compacted to a density equal to at least 100% of that obtained by compacting a sample of the material in accordance with ASTM D 698.
  - 2. The subgrade shall be compacted at a moisture content which is approximately that required to produce the maximum density indicated by the above test method. The Contractor shall dry or add moisture to the subgrade when required to provide a uniformly compacted and acceptable subgrade.

#### 3.02 TOLERANCES

- A. A tolerance of plus or minus 1/2 inch from the established grade will be permitted after the subgrade has been graded to a uniform surface.

### 3.03 PROTECTION OF SUBGRADE

- A. Ditches and drains shall be provided and maintained when required to satisfactorily drain the subgrade. Where previously approved subgrade is damaged by natural causes, by hauling equipment, or by other traffic, the Contractor shall restore the subgrade to the required lines, grades, and typical sections and to the required density at no cost to the Owner.

END OF SECTION 31 22 16



## SECTION 31 23 00 - EXCAVATION

### PART 1- GENERAL

#### 1.01 SECTION INCLUDES

- A. Excavating for building volume below grade, footings, pile caps, slabs-on-grade, paving, site structures, and utilities within the building.
- B. Trenching for utilities outside the building to utility main connections.

#### 1.02 RELATED SECTIONS

- A. Section 01 73 00 - Execution: General requirements for dewatering of excavations and water control.
- B. Section 31 22 00 - Grading: Soil removal from surface of site.
- C. Section 31 22 00 - Grading: Grading.
- D. Section 31 23 23 - Fill and Backfill: Fill materials, filling, and compacting.
- E. Section 31 23 33 - Trenching for Site Utilities: Excavating for utility trenches outside the building to utility main connections.
- F. Section 31 37 00 - Riprap.
- G. Section 33 46 00 - Subdrainage: Filter aggregate and filter fabric for foundation drainage systems.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for general requirements applicable to unit prices for excavation.
- B. Unit Price: Excavating Soil Materials:
  - 1. Measurement method: By the cubic foot.
  - 2. Includes: Excavating to required elevations, loading and placing materials in stockpile.
  - 3. Does Not Include Over-Excavation: Payment will not be made for over-excavated work nor for replacement materials.
- C. See Section 31 23 23 - Fill and Backfill, for measurement and payment provisions related to fill.

#### 1.04 PROJECT CONDITIONS

- A. Verify that survey bench mark and intended elevations for the Work are as indicated.
- B. Protect plants, lawns, rock outcroppings, and other features to remain.
- C. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

### PART 2 - PRODUCTS - NOT USED

### PART 3 – EXECUTION

#### 3.01 PREPARATION

- A. Identify required lines, levels, contours, and datum locations.
- B. See Section 31 22 00 for additional requirements.

### 3.02 EXCAVATING

- A. Underpin adjacent structures which may be damaged by excavating work.
- B. Excavate to accommodate new structures and construction operations.
- C. Notify Engineer of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- D. Preparation for Piling Work: Excavate to working elevations. Coordinate special requirements for piling.
- E. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.
- F. Do not interfere with 45 degree bearing splay of foundations.
- G. Cut utility trenches wide enough to allow inspection of installed utilities.
- H. Hand trim excavations. Remove loose matter.
- I. Remove lumped subsoil, boulders, and rock up to 1/3 cu yd measured by volume.
- J. Correct areas that are over-excavated and load-bearing surfaces that are disturbed; see Section 31 23 23.
- K. Grade top perimeter of excavation to prevent surface water from draining into excavation.
- L. Remove excavated material that is unsuitable for re-use from site.
- M. Stockpile excavated material to be re-used in area designated on site in accordance with Section 31 22 00.
- N. Remove excess excavated material from site.

### 3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 – Quality Requirements, for general requirements for field inspection and testing.
- B. Provide for visual inspection of load-bearing excavated surfaces before placement of foundations.

### 3.04 PROTECTION

- A. Prevent displacement of banks and keep loose soil from falling into excavation; maintain soil stability.
- B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.

END OF SECTION 31 23 00

## SECTION 31 23 23 - FILL AND BACKFILL

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Filling, backfilling, and compacting for building volume below grade.
- B. Backfilling and compacting for utilities outside the building to utility main connections.
- C. Filling holes, pits, and excavations generated as a result of removal (demolition) operations.

#### 1.02 RELATED SECTIONS

- A. Section 31 22 00 - Grading: Removal and handling of soil to be re-used.
- B. Section 31 22 00 - Grading: Site grading.
- C. Section 31 23 00 - Excavation: Removal and handling of soil to be re-used.
- D. Section 31 23 33 - Trenching for Site Utilities: Excavating for utility trenches outside the building to utility main connections.
- E. Section 31 37 00 - Riprap.
- F. Section 33 46 00 - Subdrainage: Filter aggregate and filter fabric for foundation drainage systems.
- G. Section 03 30 00 - Cast-in-Place Concrete.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for general requirements applicable to unit prices for earthwork.

#### 1.04 REFERENCES

- A. AASHTO T 180 - Standard Specification for Moisture-Density Relations of Soils Using a 10-lb Rammer and a 18 in. Drop; American Association of State Highway and Transportation Officials; 2001 (2004).
- B. ASTM C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates; 2006.
- C. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup>); 2000a.
- D. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method; 2000.
- E. ASTM D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>); 2002.
- F. ASTM D 2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method; 1994(R 2001).
- G. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System); 2000.
- H. ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth); 2005.
- I. ASTM D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth); 2005.
- J. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils; 2005.

## 1.05 DEFINITIONS

- A. Finish Grade Elevations: Indicated on drawings.
- B. Subgrade Elevations: 4 inches below finish grade elevations indicated on drawings, unless otherwise indicated.

## 1.06 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.
- B. Fill Composition Test Reports: Results of laboratory tests on proposed and actual materials used.
- C. Compaction Density Test Reports.

## 1.07 PROJECT CONDITIONS

- A. Provide sufficient quantities of fill to meet project schedule and requirements. When necessary, store materials on site in advance of need.
- B. When fill materials need to be stored on site, locate stockpiles where indicated.
  - 1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
  - 2. Prevent contamination.
  - 3. Protect stockpiles from erosion and deterioration of materials.
- C. Verify that survey bench marks and intended elevations for the Work are as indicated.

## PART 2 - PRODUCTS

### 2.01 FILL MATERIALS

- A. Materials shall conform to the respective specifications and other requirements specified below.
  - 1. Granular Material: Shall conform to the gradation requirements of ASTM D 693 size No. 67.
  - 2. Stone Bedding: Shall conform to Class I, 1/4 inch to 1 1/2-inch graded stone bedding, as described in ASTM D 2321.
  - 3. Portland Cement Concrete: Shall conform to ASTM C-94, with a 28-day compressive strength of 3,000 pounds per square inch. Concrete shall be protected from freezing and moisture loss for 7 days.

### 2.02 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for general requirements for testing and analysis of soil material.
- B. Where fill materials are specified by reference to a specific standard, test and analyze samples for compliance before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Identify required lines, levels, contours, and datum locations.

### 3.02 PREPARATION

- A. Scarify and proof roll subgrade surface to a depth of 6 inches to identify soft spots.
- B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.
- C. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- D. Until ready to fill, maintain excavations and prevent loose soil from falling into excavation.

### 3.03 BACKFILLING

- A. Except for special materials for pavements, the remainder of the trench shall be backfilled with ASTM 2487 Class I, II, III or IV material that is free of stones larger than 6 inches in any dimension or one-half the layered thickness, whichever is smaller. Each layer shall be compacted to not less than the minimum density specified as applicable to the particular area per Section 31 22 00 - Grading, of these specifications. Equipment for compacting backfill in trenches and excavation shall be especially selected for the type of material used in the backfill. Generally, vibrating type equipment shall be utilized for non-cohesive soils and impact type equipment shall be used for cohesive soils.
- B. Excavated Space: For manholes, wet wells, piers and similar structures shall be free of all debris prior to placing backfill. Remove all concrete forms. Place backfill in 8-inch thick layers and thoroughly compact each layer with mechanical tampers as necessary to prevent subsequent settlement. Extend backfill to indicated finish grade.
- C. Equipment shall not be allowed to pass over pipe until 3 feet of compacted cover has been placed over the pipe.

### 3.04 EXCESS WATER CONTROL

- A. General: Grade and maintain all areas of the site to preclude surface runoff into excavations and prevent ponding of water.
- B. Dewatering: Excavations should be kept free of surface water and/or groundwater. Provide and maintain at all times the necessary means and devices to prevent water from entering the excavations and for removing all water entering the excavations.
- C. Softened Subgrade: Remove all soil softened or eroded by the presence of water and replace with suitable backfill material.

### 3.05 TOLERANCES

- A. Top Surface of General Filling: Plus or minus 1 inch from required elevations.
- B. Top Surface of Filling Under Paved Areas: Plus or minus 1 inch from required elevations.

### 3.06 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for general requirements for field inspection and testing.
- B. Perform compaction density testing on compacted fill in accordance with ASTM D1556, ASTM D2167, ASTM D2922, or ASTM D3017.
- C. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D 698 ("standard Proctor"), ASTM D 1557 ("modified Proctor"), or AASHTO T 180.

- D. If tests indicate work does not meet specified requirements, remove work, replace and retest.

### 3.07 CLEAN-UP

- A. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.
- B. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION 31 23 23

## SECTION 31 23 23.23 - PROOF ROLLING

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. The Drawings and provisions of the General Conditions, Supplemental Conditions, and Division 1 are included as part of this Section as though bound herein.
- B. Section 260 of the North Carolina Department of Transportation "Standard Specification for Roads and Structures" dated July 2006.

#### 1.02 WORK INCLUDED

- A. The work covered by this section consists of the Contractor furnishing and operating heavy pneumatic tired compaction equipment for compacting and testing the roadway areas for stability and uniformity of compaction.

### PART 2 – PRODUCTS

#### 2.01 EQUIPMENT

- A. The equipment shall consist of 4 rubber-tired wheels mounted on a rigid steel frame. The wheels shall be evenly spaced in one line across the width of the roller and shall be arranged in such a manner that all wheels will carry approximately equal loads when operated over an uneven surface. The maximum center-to-center spacing between adjacent wheels shall not exceed 32 inches. The compacting equipment shall have a suitable body for ballast loading with such capacity that the gross load shall be from 48 to 50 tons unless otherwise permitted by the Owner's Representative in writing. Other equipment of equal or better effectiveness may be substituted with written permission from the Owner's Representative.
- B. The tires shall be operated at inflation pressures between 68 to 72 pounds per square inch unless otherwise permitted by the Owner's Representative in writing. The tires shall be inflated with air only; no liquid shall be used.
- C. Ballast to obtain the weight directed by the Owner's Representative shall consist of bulk, sand, bulk stone, bags of sand, stone, or other materials of known unit weight such that the total weight of the ballast used can be readily determined at all times. There shall be a sufficient amount of ballast available to load the equipment to a maximum gross weight of 50 tons. The loaded roller shall be so constructed that it will not trap water that will add weight to the ballast.
- D. Rubber tired or other types of tractive equipment may be used for operation of this equipment on the roadbed. The entire assembly including motivating equipment shall be capable of executing a 180-degree turn on a 27-foot wide area.

### PART 3 – EXECUTION

#### 3.1 CONSTRUCTION METHODS

- A. After the roadway areas have been completed to within 0.50 foot of final grade, these areas shall then be compacted and tested with one coverage, unless otherwise directed by the Owner's Representative, of a heavy pneumatic tired roller meeting the equipment requirements. A coverage is considered that state in the rolling procedure when the entire width of the area being proof rolled has been in contact with the pneumatic tires of the roller. The roller shall be

operated in a systematic manner so that the number of coverages over all areas to be proof rolled can be readily determined and recorded.

- B. The equipment shall be operated at a speed between 225 and 300 feet per minute.
- C. Proof rolling shall be done only in the presence of the Owner's Representative.
- D. If it becomes necessary to take corrective action, such as but not limited to underdrain installation, undercut and backfill of unsuitable material, and aeration of excessively wet material in areas that have been proof rolled, these areas shall be proof rolled again following the completion of the necessary corrections.

END OF SECTION 31 23 23.23



## SECTION 31 23 33 - TRENCHING FOR SITE UTILITIES

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Backfilling and compacting for utilities outside the building to utility main connections.

#### 1.02 RELATED SECTIONS

- A. Section 31 22 00 - Grading: Site grading.
- B. Section 31 23 00 - Excavation: Building and foundation excavating.
- C. Section 31 23 23 - Fill and Backfill: Backfilling at building and foundations.
- D. Section 33 46 00 - Subdrainage: Filter aggregate and filter fabric for foundation drainage systems.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for general requirements applicable to unit prices for earthwork.

#### 1.04 REFERENCES

- A. AASHTO T 180 - Standard Specification for Moisture-Density Relations of Soils Using a 10-lb Rammer and a 18 in. Drop; American Association of State Highway and Transportation Officials; 2001 (2004).
- B. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup>); 2000a.
- C. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method; 2000.
- D. ASTM D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>); 2002.
- E. ASTM D 2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method; 1994(R 2001).
- F. ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth); 2005.
- G. ASTM D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth); 2005.

#### 1.05 DEFINITIONS

- A. Finish Grade Elevations: Indicated on drawings.
- B. Subgrade Elevations: 4 inches below finish grade elevations indicated on drawings, unless otherwise indicated.

#### 1.06 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.
- B. Fill Composition Test Reports: Results of laboratory tests on proposed and actual materials used.

C. Compaction Density Test Reports.  
1.07 PROJECT CONDITIONS

- A. Provide sufficient quantities of fill to meet project schedule and requirements. When necessary, store materials on site in advance of need.
- B. Verify that survey bench marks and intended elevations for the Work are as indicated.
- C. Protect plants, lawns, rock outcroppings, and other features to remain.
- D. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

PART 2 - PRODUCTS

2.01 FILL MATERIALS

- A. Materials shall conform to the respective specifications and other requirements specified below.
  - 1. Granular Material: Shall conform to the gradation requirements of ASTM D 693 size No. 67.
  - 2. Stone Bedding: Shall conform to Class I, 1/4 inch to 1 1/2 inch graded stone bedding, as described in ASTM D 2321.
  - 3. Portland Cement Concrete: Shall conform to ASTM C-94, with a 28-day compressive strength of 3,000 pounds per square inch. Concrete shall be protected from freezing and moisture loss for 7 days.

2.02 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for general requirements for testing and analysis of soil material.
- B. Where fill materials are specified by reference to a specific standard, test and analyze samples for compliance before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Identify required lines, levels, contours, and datum locations.
- B. Locate, identify, and protect utilities that remain and protect from damage.

3.02 TRENCHING

- A. Notify Engineer of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- B. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.
- C. Do not interfere with 45 degree bearing splay of foundations.
- D. Cut trenches wide enough to allow inspection of installed utilities.
- E. Hand trim excavations. Remove loose matter.
- F. Remove large stones and other hard matter which could damage piping or impede consistent backfilling or compaction.
- G. Remove excavated material that is unsuitable for re-use from site.
- H. Stockpile excavated material to be re-used in area designated on site in accordance with Section

31 20 10.

- I. Remove excess excavated material from site.

### 3.03 PREPARATION FOR UTILITY PLACEMENT

- A. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.
- B. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- C. Until ready to backfill, maintain excavations and prevent loose soil from falling into excavation.

### 3.04 BACKFILLING

- A. Except for special materials for pavements, the remainder of the trench shall be backfilled with ASTM 2487 Class I, II, III or IV material that is free of stones larger than 6 inches in any dimension or one-half the layered thickness, whichever is smaller. Each layer shall be compacted to not less than the minimum density specified as applicable to the particular area per Section 31 22 00 - Grading, of these specifications. Equipment for compacting backfill in trenches and excavation shall be especially selected for the type of material used in the backfill. Generally, vibrating type equipment shall be utilized for non-cohesive soils and impact type equipment shall be used for cohesive soils.
- B. Excavated Space: For manholes, wet wells, piers and similar structures shall be free of all debris prior to placing backfill. Remove all concrete forms. Place backfill in 8-inch thick layers and thoroughly compact each layer with mechanical tampers as necessary to prevent subsequent settlement. Extend backfill to indicated finish grade.
- C. Equipment shall not be allowed to pass over pipe until 3 feet of compacted cover has been placed over the pipe.

### 3.05 BEDDING AND FILL AT SPECIFIC LOCATIONS

- A. Bedding material requirements as specified hereinafter are due to the properties of pipe materials and trench depths. Whenever the width of the trench at the top of the pipe cannot be maintained for any reason whatsoever, the Contractor shall immediately stop all work in connection with the preparation of the pipe bed and shall notify the Owner's Representative. The Owner's Representative will select the proper class of pipe bedding to be provided by the Contractor. Any and all changes to class of pipe bedding made necessary by the Contractor not being able to maintain the conditions specified shall be provided by the Contractor at his expense and without any change in the contract price.
  1. Bedding Materials: Shall be classified in accordance with ASTM D 2487, and are described in Table 2221-1. Bedding, haunching, and initial backfill material shall be free of stones larger than 1/2 inch in diameter and shall not be Class V soil.

TABLE 2221-1

#### DESCRIPTION OF EMBEDMENT MATERIAL CLASSIFICATIONS

| <u>SOIL CLASS</u> | <u>SOIL TYPE</u> | <u>DESCRIPTION OF MATERIAL CLASSIFICATION</u>                                   |
|-------------------|------------------|---------------------------------------------------------------------------------|
|                   | ---              | Manufactured angular, granular material, 1/4 to 1 1/2 inches (6 to 40 mm) size, |

|                       |                  |                                                                                                                                                          |
|-----------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| CLASS I<br>SOILS*     |                  | including materials having regional significance such as crushed stone or rock, broken coral, crushed slag, cinders, or crushed shells.                  |
|                       | GW               | Well-graded gravels and gravel-sand mixtures, little or no fines. 50% or more retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.   |
|                       | GP               | Poorly graded gravels and gravel-sand mixtures, little or no fines. 50% or more retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean. |
| CLASS II<br>SOILS **  | SW               | Well-graded sands and gravelly sands, little or no fines. More than 50% passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.              |
|                       | SP               | Poorly graded sands and gravelly sands, little or no fines. More than 50% passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.            |
|                       | GM               | Silty gravels, gravel-sand-silt mixtures. 50% or more retained on No. 4 sieve. More than 50% retained on No. 200 sieve.                                  |
| <u>SOIL CLASS</u>     | <u>SOIL TYPE</u> | <u>DESCRIPTION OF MATERIAL CLASSIFICATION</u>                                                                                                            |
| CLASS III<br>SOILS*** | GC               | Clayey gravels, gravel-sand-clay mixtures. 50% or more retained on No. 4 sieve. More than 50% retained on No. 200 sieve.                                 |
|                       | SM               | Silty sands, sand-silt mixtures. More than 50% passes No. 4 sieve. More than 50% retained on No. 200 sieve.                                              |
|                       | SC               | Clayey sands, sand-clay mixtures. More than 50% passes No. 4 sieve. More than 50% retained on No. 200 sieve.                                             |
|                       | ML               | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands. Liquid limit 50% or less. 50% or more passes                                   |

No. 200 sieve.

|                |    |                                                                                                                                                                |
|----------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. Liquid limit 50% or less. 50% or more passes No. 200 sieve. |
| CLASS IV SOILS | MH | Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts. Liquid limit Greater than 50%. 50% or more passes No. 200 sieve.                |
|                | CH | Inorganic clays of high plasticity, fat clays. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.                                                |
|                | OL | Organic silts and organic silty clays of low plasticity. Liquid limit 50% or less. 50% or more passes No. 200 sieve.                                           |
|                | OH | Organic clays of medium to high plasticity. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.                                                   |
|                | PT | Peat, muck and other highly organic soils.                                                                                                                     |

\* Soils defined as Class 1 materials are not defined in ASTM D2487.

\*\* In accordance with ASTM D 2487, less than 5% pass No. 200 sieve.

\*\*\* In accordance with ASTM D 2487, more than 12% pass No. 200 sieve. Soils with 5% to 12% pass No. 200 sieve fall in borderline classification; e.g., GP-GC.

2. Rigid Pipe (DIP pipe): Bedding, haunching, and initial backfill for rigid pipe shall be placed as specified on the plans. The applicable trench bedding conditions shall be dependent on type of pipe and depth of cut, as specified herein.
3. Flexible Pipe (PVC Pipe): Flexible pipe bedding shall conform to ASTM D2321 and consist of bedding the pipe in compacted granular material placed on a flat trench bottom, as shown in the plans.

### 3.06 TOLERANCES

- A. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.
- B. Top Surface of Backfilling Under Paved Areas: Plus or minus 1 inch from required elevations.

### 3.07 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for general requirements for field inspection and testing.
- B. Perform compaction density testing on compacted fill in accordance with ASTM D1556, ASTM D2167, ASTM D2922, or ASTM D3017.

- C. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D 698 ("standard Proctor"), ASTM D 1557 ("modified Proctor"), or AASHTO T 180.
- D. If tests indicate work does not meet specified requirements, remove work, replace and retest.

### 3.08 CLEAN-UP

- A. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.

END OF SECTION 31 23 33

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## SECTION 31 25 00 - TEMPORARY EROSION AND SEDIMENTATION CONTROL

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Prevention of erosion due to construction activities.
- B. Prevention of sedimentation of waterways, open drainage ways, and storm and sanitary sewers due to construction activities.
- C. Restoration of areas eroded due to insufficient preventive measures.
- D. Performance bond.
- E. Compensation of Owner for fines levied by authorities having jurisdiction due to non-compliance by Contractor.

#### 1.02 RELATED SECTIONS

- A. Section 31 10 00 - Site Clearing: Limits on clearing; disposition of vegetative clearing debris.
- B. Section 31 22 00 - Grading: Temporary and permanent grade changes for erosion control.
- C. Section 31 37 00 - Riprap: Temporary and permanent stabilization using riprap.
- D. Section 32 11 23 - Aggregate Base Course: Temporary and permanent roadways.
- E. Section 32 92 19 - Seeding: Permanent turf for erosion control.
- F. Section 32 92 23 - Sodding: Permanent turf for erosion control.

#### 1.03 REFERENCES

- A. ASTM D 4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus; 2005.
- B. ASTM D 4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity; 1999a (Reapproved 2004).
- C. ASTM D 4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles; 2004.
- D. ASTM D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles; 1991 (Reapproved 2003).
- E. ASTM D 4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile; 2004.
- F. ASTM D 4873 - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples; 2002.
- G. EPA (NPDES) - National Pollutant Discharge Elimination System (NPDES), Construction General Permit; current edition; <http://cfpub.epa.gov/npdes/stormwater/cgp.cfm>.
- H. FHWA FLP-94-005 - Best Management Practices for Erosion and Sediment Control; Federal Highway Administration; 1995.
- I. USDA TR-55 - Urban Hydrology for Small Watersheds; USDA Natural Resources Conservation Service; 1986.

#### 1.04 PERFORMANCE REQUIREMENTS

- A. Comply with all requirements of U.S. Environmental Protection Agency for erosion and sedimentation control, as specified for the National Pollutant Discharge Elimination System (NPDES), Phases I and II, under requirements for the 2003 Construction General Permit (CGP), whether the project is required by law to comply or not.
- B. Also comply with all more stringent requirements of State of North Carolina Erosion and

- Sedimentation Control Manual.
- C. Comply with all requirements of NCDENR Division of Land Quality for erosion and sedimentation control.
  - D. Do not begin clearing, grading, or other work involving disturbance of ground surface cover until applicable permits have been obtained; furnish all documentation required to obtain applicable permits.
    - 1. Owner will obtain permits and pay for securities required by authority having jurisdiction.
    - 2. Owner will withhold payment to Contractor equivalent to all fines resulting from non-compliance with applicable regulations.
  - E. Provide to Owner a Performance Bond covering erosion and sedimentation preventive measures only, in an amount equal to 100 percent of the cost of erosion and sedimentation control work.
  - F. Timing: Put preventive measures in place as soon as possible after disturbance of surface cover and before precipitation occurs.
  - G. Storm Water Runoff: Control increased storm water runoff due to disturbance of surface cover due to construction activities for this project.
    - 1. Prevent runoff into storm and sanitary sewer systems, including open drainage channels, in excess of actual capacity or amount allowed by authorities having jurisdiction, whichever is less.
    - 2. Anticipate runoff volume due to the most extreme short term and 24-hour rainfall events that might occur in 25 years.
  - H. Erosion On Site: Minimize wind, water, and vehicular erosion of soil on project site due to construction activities for this project.
    - 1. Control movement of sediment and soil from temporary stockpiles of soil.
    - 2. Prevent development of ruts due to equipment and vehicular traffic.
    - 3. If erosion occurs due to non-compliance with these requirements, restore eroded areas at no cost to Owner.
  - I. Erosion Off Site: Prevent erosion of soil and deposition of sediment on other properties caused by water leaving the project site due to construction activities for this project.
    - 1. Prevent windblown soil from leaving the project site.
    - 2. Prevent tracking of mud onto public roads outside site.
    - 3. Prevent mud and sediment from flowing onto sidewalks and pavements.
    - 4. If erosion occurs due to non-compliance with these requirements, restore eroded areas at no cost to Owner.
  - J. Sedimentation of Waterways On Site: Prevent sedimentation of waterways on the project site, including rivers, streams, lakes, ponds, open drainage ways, storm sewers, and sanitary sewers.
    - 1. If sedimentation occurs, install or correct preventive measures immediately at no cost to Owner; remove deposited sediments; comply with requirements of authorities having jurisdiction.
    - 2. If sediment basins are used as temporary preventive measures, pump dry and remove deposited sediment after each storm.
  - K. Sedimentation of Waterways Off Site: Prevent sedimentation of waterways off the project site, including rivers, streams, lakes, ponds, open drainage ways, storm sewers, and sanitary sewers.
    - 1. If sedimentation occurs, install or correct preventive measures immediately at no cost to Owner; remove deposited sediments; comply with requirements of authorities having jurisdiction.
  - L. Open Water: Prevent standing water that could become stagnant.
  - M. Maintenance: Maintain temporary preventive measures until permanent measures have been established.

## 1.05 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.
- B. Certificate: Mill certificate for silt fence fabric attesting that fabric and factory seams comply with specified requirements, signed by legally authorized official of manufacturer; indicate actual minimum average roll values; identify fabric by roll identification numbers.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

- A. Mulch: Use one of the following:
  - 1. Straw or hay.
  - 2. Wood waste, chips, or bark.
  - 3. Erosion control matting or netting.
  - 4. Cutback asphalt.
  - 5. Polyethylene film, where specifically indicated only.
- B. Grass Seed For Temporary Cover: Select a species appropriate to climate, planting season, and intended purpose. If same area will later be planted with permanent vegetation, do not use species known to be excessively competitive or prone to volunteer in subsequent seasons.
- C. Silt Fence Fabric: Polypropylene geotextile resistant to common soil chemicals, mildew, and insects; non-biodegradable; in longest lengths possible; fabric including seams with the following minimum average roll lengths:
  - 1. Average Opening Size: 30 U.S. Std. Sieve (0.600 mm), maximum, when tested in accordance with ASTM D 4751.
  - 2. Permittivity:  $0.05 \text{ sec}^{-1}$ , minimum, when tested in accordance with ASTM D 4491.
  - 3. Ultraviolet Resistance: Retaining at least 70 percent of tensile strength, when tested in accordance with ASTM D 4355 after 500 hours exposure.
  - 4. Tensile Strength: 100 lb-f (450 N), minimum, in cross-machine direction; 124 lb-f (550 N), minimum, in machine direction; when tested in accordance with ASTM D 4632.
  - 5. Elongation: 15 to 30 percent, when tested in accordance with ASTM D 4632.
  - 6. Tear Strength: 55 lb-f (245 N), minimum, when tested in accordance with ASTM D 4533.
  - 7. Color: Manufacturer's standard, with embedment and fastener lines preprinted.
  - 8. Manufacturers:
    - a. BP Amoco, Amoco Fabrics and Fibers: [www.geotextile.com](http://www.geotextile.com).
    - b. TC Mirafi: [www.tcmirafi.com](http://www.tcmirafi.com).
    - c. Synthetic Industries: [www.fixsoil.com](http://www.fixsoil.com).
- D. Silt Fence Posts: One of the following, minimum 5 feet (1500 mm) long:
  - 1. Steel U- or T-section, with minimum mass of 1.33 lb per linear foot (1.98 kg per linear m).
- E. Gravel: See Section 32 11 23 for aggregate.
- F. Riprap: See Section 31 37 00.

## PART 3 – EXECUTION

### 3.01 EXAMINATION

- A. Examine site and identify existing features that contribute to erosion resistance; maintain such existing features to greatest extent possible.

### 3.02 PREPARATION

- A. Schedule work so that soil surfaces are left exposed for the minimum amount of time.

### 3.03 SCOPE OF PREVENTIVE MEASURES

- A. In all cases, if permanent erosion resistant measures have been installed temporary preventive measures are not required.
- B. Construction Entrances: Traffic-bearing aggregate surface.
  - 1. Width: As required; 20 feet (7 m), minimum.
  - 2. Length: 50 feet (16 m), minimum.
  - 3. Provide at each construction entrance from public right-of-way.
  - 4. Where necessary to prevent tracking of mud onto right-of-way, provide wheel washing area out of direct traffic lane, with drain into sediment trap or basin.
- C. Linear Sediment Barriers: Made of silt fences.
  - 1. Provide linear sediment barriers:
    - a. Along downhill perimeter edge of disturbed areas, including soil stockpiles.
    - b. Along the top of the slope or top bank of drainage channels and swales that traverse disturbed areas.
    - c. Along the toe of cut slopes and fill slopes.
    - d. Perpendicular to flow across the bottom of existing and new drainage channels and swales that traverse disturbed areas or carry runoff from disturbed areas; space at maximum of 200 feet (60 m) apart.
    - e. Across the entrances to culverts that receive runoff from disturbed areas.
  - 2. Space sediment barriers with the following maximum slope length upslope from barrier:
    - a. Slope of Less Than 2 Percent: 100 feet (30 m)..
    - b. Slope Between 2 and 5 Percent: 75 feet (23 m).
    - c. Slope Between 5 and 10 Percent: 50 feet (15 m).
    - d. Slope Between 10 and 20 Percent: 25 feet (7.5 m).
    - e. Slope Over 20 Percent: 15 feet (4.5 m).
- D. Storm Drain Curb Inlet Sediment Trap: Protect each curb inlet using the following measures:
  - 1. Filter fabric wrapped around hollow concrete blocks blocking entire inlet face area; use one piece of fabric wrapped at least 1-1/2 times around concrete blocks and secured to prevent dislodging; orient cores of blocks so runoff passes into inlet.
- E. Storm Drain Drop Inlet Sediment Traps: As detailed on drawings.
- F. Temporary Splash Pads: Stone aggregate over filter fabric; size to suit application; provide at downspout outlets and storm water outlets.
- G. Soil Stockpiles: Protect using one of the following measures:
  - 1. Cover with polyethylene film, secured by placing soil on outer edges.
  - 2. Cover with mulch at least 4 inches (100 mm) thickness of pine needles, sawdust, bark, wood chips, or shredded leaves, or 6 inches (150 mm) of straw or hay.
- H. Mulching: Use only for areas that may be subjected to erosion for less than 6 months.
  - 1. Wood Waste: Use only on slopes 3:1 or flatter; no anchoring required.
  - 2. Asphalt: Use only where no traffic, either vehicular or pedestrian, is anticipated.
- I. Temporary Seeding: Use where temporary vegetated cover is required.

### 3.04 INSTALLATION

- A. The Contractor shall install the erosion control construction measures as shown on the contract drawings, except that should circumstances dictate that extra precaution be taken to prohibit erosion and sedimentation on the project, the Contractor will, at his own expense, take preventative measures as needed.
- B. The Contractor is required to maintain all erosion and sediment control facilities to insure proper performance throughout the construction phase and until such time all disturbed areas are permanently stabilized.
- C. Upon completion of construction or successful permanent stabilization of all areas which were disturbed before or during construction operations or as indicated on the construction drawings, whichever occurs last, the Contractor shall remove all temporary erosion and sediment control devices and facilities from the project site. The Contractor shall retain these items for future use or properly dispose of these items offsite.
- D. The Contractor shall provide temporary or permanent stabilization with ground cover on all perimeter dikes, swales, ditches, perimeter slopes and all slopes steeper than 3:1 (horizontal to vertical) within 7 calendar days from the last land disturbing activity. All other areas shall be stabilized with ground cover within 14 days from the last land disturbing activity.

### 3.05 MAINTENANCE

- A. Inspect preventive measures weekly, within 24 hours after the end of any storm that produces 0.5 inches (13 mm) or more rainfall at the project site, and daily during prolonged rainfall.
- B. Repair deficiencies immediately.
- C. Silt Fences:
  - 1. Promptly replace fabric that deteriorates unless need for fence has passed.
  - 2. Remove silt deposits that exceed one-third of the height of the fence.
  - 3. Repair fences that are undercut by runoff or otherwise damaged, whether by runoff or other causes.
- D. Clean out temporary sediment control structures weekly and relocate soil on site.
- E. Place sediment in appropriate locations on site; do not remove from site.

### 3.06 CLEAN UP

- A. Remove temporary measures after permanent measures have been installed, unless permitted to remain by Engineer.
- B. Clean out temporary sediment control structures that are to remain as permanent measures.
- C. Where removal of temporary measures would leave exposed soil, shape surface to an acceptable grade and finish to match adjacent ground surfaces.

END OF SECTION 31 25 00

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## SECTION 313116 - TERMITE CONTROL

## PART 1 - GENERAL

## 1.1 SUMMARY

## A. Section Includes:

1. Soil treatment.

## 1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

## 1.3 ACTION SUBMITTALS

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

1. Include the EPA-Registered Label for termiticide products.
2. Include certificate of registration with North Carolina Department of Agriculture and Consumer Services Structural Pest Control Division (NCDOA).

## 1.4 INFORMATIONAL SUBMITTALS

## A. Qualification Data: For qualified Installer.

## B. Product Certificates: For each type of termite control product.

## C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:

1. Date and time of application.
2. Moisture content of soil before application.
3. Termiticide brand name and manufacturer.
4. Quantity of undiluted termiticide used.
5. Dilutions, methods, volumes used, and rates of application.
6. Areas of application.
7. Water source for application.

## D. Sample Warranties: For special warranties.

## 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project

is located and who employs workers trained and approved by manufacturer to install manufacturer's products.

1. Installer shall be licensed as a Pest Control Operator (PCO) by NCDOA.

## 1.6 FIELD CONDITIONS

### A. Soil Treatment:

1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
2. Related Work: Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

## 1.7 WARRANTY

- ### A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites, including Formosan termites (*Coptotermes*). If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

1. Warranty Period: Three years from date of Substantial Completion.

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- ### A. Source Limitations: Obtain termite control products from single source from single manufacturer.

## 2.2 SOIL TREATMENT

1. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label. **Use compatible dye in termiticide to provide visible evidence of treatment.**
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) BASF; Thermidor.
    - 2) Bayer Environmental Science.
    - 3) FMC Specialty Products.



- 4) Syngenta.
2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than three years against infestation of subterranean termites.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

#### 3.2 PREPARATION

- A. General: Prepare work areas according to the requirements of authorities having jurisdiction and according to manufacturer's written instructions before beginning application and installation of termite control treatment(s). Remove extraneous sources of wood cellulose and other edible materials, such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.
  1. Fit filling hose connected to water source at the site with a backflow preventer, according to requirements of authorities having jurisdiction.

#### 3.3 APPLYING SOIL TREATMENT

- A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.
  1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
  2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.

3. Masonry: Treat voids.
4. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.

B. Post warning signs in areas of application.

C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

### 3.4 PROTECTION

A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.

B. Protect termiticide solution dispersed in treated soils and fills from being diluted by exposure to water spillage or weather until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

### 3.5 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of termite-control-treatment Installer. Include annual maintenance as required for proper performance according to the product's EPA-Registered Label and manufacturer's written instructions. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

B. Continuing Maintenance Proposal: Provide from termite-control-treatment Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1. Include annual inspection for termite activity and effectiveness of termite treatment according to manufacturer's written instructions.

END OF SECTION 313116

SECTION 31 37 00 - RIPRAP

PART 1- GENERAL

1.01 SECTION INCLUDES

- A. Riprap.

1.02 RELATED SECTIONS

- A. Section 31 23 23 - Fill and Backfill: Aggregate requirements.

1.03 UNIT PRICES - MEASUREMENT AND PAYMENT

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Riprap: By the square yard (meter) of riprap area; summing the areas of individual layers, of riprap. Includes supply and placing riprap.

1.04 QUALITY ASSURANCE

- A. Perform Work in accordance with State of North Carolina Highways standard.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Riprap: Provide in accordance with State of North Carolina Highways standards.
- B. Aggregate: Granular fill as specified in Section 32 11 23.
- C. Geotextile Fabric: Non-biodegradable, woven, and Type II.

PART 3 - EXECUTION

3.01 PLACEMENT

- A. Place geotextile fabric over substrate, lap edges and ends.
- B. Place riprap at culvert pipe ends, embankment slopes, and as indicated on construction documents.

END OF SECTION 31 37 00

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## SECTION 32 11 23 - AGGREGATE BASE COURSE

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Aggregate base course.
- B. Paving aggregates.

#### 1.02 RELATED SECTIONS

- A. Section 31 22 00 - Grading: Preparation of site for base course.
- B. Section 31 23 23 - Fill and Backfill: Compacted fill under base course.
- C. Section 31 23 33 - Trenching for Site Utilities: Compacted fill over utility trenches under base course.
- D. Section 33 49 13 - Manholes and Covers: Manholes including frames.
- E. Section 32 11 26 - Bituminous Concrete Paving: Binder and finish asphalt courses.
- F. Section 31 23 23 - Fill and Backfill: Topsoil fill at areas adjacent to aggregate base course.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for general requirements applicable to unit prices for earthwork.
- B. Coarse Aggregate Type C: By the cubic yard. Includes supplying aggregate material, stockpiling, scarifying substrate surface, placing, and compacting.
- C. Fine Aggregate Type B: By the cubic yard. Includes supplying aggregate material, stockpiling, scarifying substrate surface, placing where required, and compacting.

#### 1.04 REFERENCES

- A. AASHTO M 147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses; American Association of State Highway and Transportation Officials; 1965 (2004).
- B. AASHTO T 180 - Standard Specification for Moisture-Density Relations of Soils Using a 10-lb Rammer and a 18 in. Drop; American Association of State Highway and Transportation Officials; 2001 (2004).
- C. ASTM C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates; 2006.
- D. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup>); 2000a.
- E. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method; 2000.
- F. ASTM D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>); 2002.
- G. ASTM D 2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method; 1994(R 2001).
- H. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System); 2000.
- I. ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth); 2005.
- J. ASTM D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear

Methods (Shallow Depth); 2005.

- K. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils; 2005.

#### 1.05 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.
- B. Aggregate Composition Test Reports: Results of laboratory tests on proposed and actual materials used.
- C. Compaction Density Test Reports.

#### 1.06 PROJECT CONDITIONS

- A. Provide sufficient quantities of aggregate to meet project schedule and requirements. When necessary, store materials on site in advance of need.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS

- A. General Requirements: Aggregate base course material shall consist of crushed stone, crushed or uncrushed gravel or other similar material having hard, strong, durable, particle free of adherent coatings and comply with the gradation requirements contained in Section 520 of the NCDOT “Standard Specifications for Roads and Structures” referenced above.

#### 2.02 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for general requirements for testing and analysis of aggregate materials.
- B. Where aggregate materials are specified using ASTM D 2487 classification, test and analyze samples for compliance before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.
- D. Provide materials of each type from same source throughout the Work.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Verify substrate has been inspected, gradients and elevations are correct, and is dry.

#### 3.02 PREPARATION

- A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.
- B. Do not place aggregate on soft, muddy, or frozen surfaces.

#### 3.03 INSTALLATION

- A. The subgrade shall be prepared as called for on the plans in accordance with Section 31 22 16 of these specifications prior to placement of the base material.



- B. The aggregate material shall be placed on the subgrade with a mechanical spreader capable of placing the material to a uniform loose depth without segregation except that for areas inaccessible to a mechanical spreader, the aggregate material may be placed by other methods approved by the Owner's Representative.
- C. Where the required compacted thickness of base is 8 inches or less, the base material may be spread and compacted in one layer. Where the required compacted thickness is more than 8 inches, the base material shall be spread and compacted in 2 or more approximately equal layers. The minimum compacted thickness of any one layer shall be approximately 4 inches.
- D. Each layer of material shall have been sampled, tested, compacted and approved prior to placing succeeding layers of base material or pavement.
- E. No base material shall be placed on frozen subgrade or base.
- F. No traffic shall be allowed on the completed base course other than necessary local traffic and that developing from the operation of essential construction equipment as may be authorized by the Owner's Representative. Any defects that develop in the completed base or any damage caused by local or construction traffic shall be acceptably repaired at no cost to the Owner.
- G. The Contractor shall utilize methods of handling, hauling and placing which will minimize segregation and contamination. If segregation occurs, the Owner's Representative may require that changes be made in the Contractor's methods to minimize segregation, and may also require mixing on the roadway areas which may be necessary to correct any segregation. No additional compensation will be allowed for the work of mixing as may be required under this provision. Aggregate that is contaminated with foreign materials to the extent that the base course will not adequately serve its intended use will be removed and replaced by the Contractor at no additional cost to the Owner.

### 3.04 SHAPING AND COMPACTING

- A. Within 48 hours after beginning the placing of a layer of the base, the Contractor shall begin machining and compacting of the layer. Each layer shall be maintained to the required cross section during compaction and each layer be compacted to the required density prior to placing the next layer.
- B. Each layer of the base shall be compacted to a density equal to at least 100% of that obtained by compacting a sample of the material in accordance with AASHTO T180.
- C. The base material shall be compacted at a moisture content which is approximately that required to produce a maximum density indicated by the above test method. The Contractor shall dry or add moisture to the material when required to provide a uniformly compacted and acceptable base.
- D. The final layer of base material shall be shaped to conform to the lines, grades and typical sections shown on the plans or established by the Owner's Representative. When completed, the base course shall be smooth, hard, dense, unyielding and well bonded. A broom drag may be used in connection with the final finishing and conditioning of the surface of the base course.
- E. After final shaping and compacting of the base, the Owner's Representative will check the surface of the base for conformance to the grade and typical section and determine the base thickness.
- F. The thickness of the base shall be within a tolerance of plus or minus 0.1 feet of the base thickness required by the plans. The maximum differential between the established grade and the base within any 100-foot section shall be 0.1 feet.
- G. Where the base material is placed in a trench section, the Contractor shall provide adequate drainage through the shoulders to protect the subgrade and base until such time as the shoulders are completed.





- H. The Contractor shall maintain the surface of the base by watering, machining, and rolling or dragging when necessary to prevent damage to the base by weather or traffic.
- I. Where the base or subgrade is damaged, the Contractor shall repair the damaged area; reshape the base to required lines, grades and typical sections; and recompact the base to the required density at no cost to the Owner.

### 3.05 TOLERANCES

- A. Flatness: Maximum variation of 1/4 inch (6 mm) measured with 10 foot (3 m) straight edge.
- B. Scheduled Compacted Thickness: Within 1/4 inch.
- C. Variation From Design Elevation: Within 1/2 inch.

### 3.06 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for general requirements for field inspection and testing.
- B. Compaction density testing will be performed on compacted aggregate base course in accordance with ASTM D1556.
- C. Results will be evaluated in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D 698 ("standard Proctor").
- D. If tests indicate work does not meet specified requirements, remove work, replace and retest.

### 3.07 CLEAN-UP

- A. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.

END OF SECTION 32 11 23

## SECTION 32 11 26 - BITUMINOUS CONCRETE PAVING

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Aggregate base course.
- B. Single course bituminous concrete paving.
- C. Double course bituminous concrete paving.
- D. Surface sealer.

#### 1.02 RELATED SECTIONS

- A. Section 31 22 00 - Grading: Preparation of site for paving and base.
- B. Section 31 23 23 - Fill and Backfill: Compacted subgrade for paving.
- C. Section 33 49 13 - Manholes and Covers: Manholes, including frames.
- D. Section 32 17 23 - Pavement markings.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices for requirements applicable to this section. Measurement and payment will be as follows:
- B. Asphalt Pavement Mix (Base Course): By the ton. Includes preparing base, tack coating surfaces, placing, compacting and rolling, testing. Includes mix design, supplying to site, testing.
- C. Asphalt Pavement Mix (Binder Course): By the ton. Includes preparing base, tack coating surfaces, placing, compacting and rolling, testing. Includes mix design, supplying to site, testing.
- D. Asphalt Pavement Mix (Wearing Course): By the ton. Includes preparing base, tack coating surfaces, placing, compacting and rolling, testing. Includes mix design, supplying to site, testing.
- E. Seal Coat: By the square yard. Includes preparing surfaces and applying.

#### 1.04 REFERENCES

- A. AI MS-2 - Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types; The Asphalt Institute; 1994, Sixth Edition.
- B. AI MS-19 - A Basic Asphalt Emulsion Manual; The Asphalt Institute; Third Edition.
- C. ASTM D 946 - Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction; 1982 (Reapproved 2005).

#### 1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with State of North Carolina Highways standard.
- B. Mixing Plant: Conform to State of North Carolina Highways standard.
- C. Obtain materials from same source throughout.

#### 1.06 REGULATORY REQUIREMENTS

- A. Conform to applicable code for paving work on public property.

## 1.07 ENVIRONMENTAL REQUIREMENTS

- A. Do not place asphalt when ambient air or base surface temperature is less than 40 degrees F, or surface is wet or frozen.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

- A. Aggregate for Base Course: In accordance with State of North Carolina Highways standards.
- B. Aggregate for Binder Course: In accordance with State of North Carolina Highways standards.
- C. Aggregate for Wearing Course: In accordance with State of North Carolina Highways standards.
- D. Fine Aggregate: In accordance with State of North Carolina Highways standards.
- E. Mineral Filler: Finely ground particles of limestone, hydrated lime or other mineral dust, free of foreign matter.
- F. Primer: In accordance with State of North Carolina Highways standards.
- G. Tack Coat: Homogeneous, medium curing, liquid asphalt.

### 2.02 BASE COURSE

- A. Earth Type Base Course: If allowed in the scope of this project, shall consist of approved selected soil materials. The material shall consist of topsoil, naturally or artificially proportioned sand-clay, or sand-clay gravel obtained from locations designated or approved by the owner's representative. Earth type base course shall comply with requirements of Section 520 for materials and construction procedures. The earth type base course shall be placed on a prepared sub-grade mixed, shaped, brought to proper moisture content and compacted in accordance with these specifications or as directed by the owner's representative.
- B. Stabilized Aggregate Base Course: If allowed in the scope of this project, shall consist of properly graded mixture of natural or crushed gravel or stone, crushed slag, natural or processed sand that will readily compact to required density. Base course shall comply with requirements of Section 520 for materials and construction procedures. Stabilized aggregate base course shall be mixed, placed on a prepared sub-grade, brought to proper moisture content, and shaped. Compacted, and primed in accordance with these specifications or as directed by the owner's representative.
- C. Hot Laid Asphalt Aggregate Base Course (Black Base): If allowed in the scope of this project, shall consist of a base course of crushed stone, crushed slag, or gravel and asphalt cement mixed in an approved plant and constructed on a prepared sub-grade. Hot laid asphalt aggregate base course shall comply with requirements of Section 610 for materials and construction procedures.

### 2.03 TACK COAT

- A. Asphalt Emulsion Grade SS01: This grade may be diluted with not more than 50% water. Note: ss01 shall meet requirements as specified in section 605 of standard specs manual (latest edition) of the North Carolina Department of Transportation.
- B. Apply to contract surfaces of previously constructed bituminous concrete or Portland cement

concrete and similar surfaces. Distribute at rate of 0.05 to 0.15 gallons per square yard of surface.

- C. Apply tack coat by brush to contact surfaces of curbs, gutters, manholes, and other structures projecting into or abutting asphalt concrete pavement.
- D. Allow tack coat to dry to proper conditions of tackiness to receive paving before proceeding with work.

#### 2.04 HOT LAID ASPHALTIC CONCRETE SURFACE COURSE

- A. Mineral aggregate and asphalt cement shall conform to Section 610 for materials and construction procedures.
- B. Aggregate and asphalt cement shall be mixed in an approved plant in such proportions that compositions by weight of finished mixture shall be within range limits as specified in Section 610.
- C. The surface course shall be constructed on a prepared base in accordance with these specifications and to the lines, grades, and typical cross section shown on the plans or as directed by owner's representative.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Verify that compacted subgrade is dry and ready to support paving and imposed loads.
- B. Verify gradients and elevations of base are correct.

#### 3.02 BASE COURSE

- A. Place and compact base course.

#### 3.03 PREPARATION - TACK COAT

- A. Apply tack coat in accordance with manufacturer's instructions.
- B. Apply tack coat on asphalt or concrete surfaces over subgrade surface at uniform rate of 1/3 gal/sq yd.
- C. Coat surfaces of manhole frames with oil to prevent bond with asphalt pavement. Do not tack coat these surfaces.

#### 3.04 PLACING ASPHALT PAVEMENT - SINGLE COURSE

- A. Install Work in accordance with State of North Carolina Highways standards.
- B. Place asphalt within 24 hours of applying primer or tack coat.
- C. Compact pavement by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.
- D. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.

#### 3.05 PLACING ASPHALT PAVEMENT - DOUBLE COURSE

- A. Place asphalt binder course within 24 hours of applying primer or tack coat.
- B. Place wearing course within two hours of placing and compacting binder course.

- C. Compact pavement by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.

- D. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.

### 3.06 TOLERANCES

- A. Flatness: Maximum variation of 1/4 inch measured with 10 foot straight edge.
- B. Variation from True Elevation: Within 1/2 inch.

### 3.07 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for general requirements for quality control.
- B. Provide field inspection and testing. Take samples and perform tests in accordance with AI MS-2.

END OF SECTION 32 11 26

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## SECTION 32 16 13 - CONCRETE CURBING

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. The general provisions of Division 1 shall govern this section.

#### 1.02 DESCRIPTION OF WORK

- A. Extent of concrete curbing is shown on the drawings.
- B. Concrete curbing shall be constructed as detailed on the drawing. All curbing shall be "formed" in the road curvature and radii. Extruded curbing is permitted on tangents.

#### 1.03 QUALITY ASSURANCE

- A. All work and materials shall comply with North Carolina Department of Transportation standard specifications, latest edition.

#### 1.04 JOB CONDITIONS

- A. Concrete curb shall be applied only when ambient temperature is above 50 degrees F and when temperature has not been below 35 degrees F for 12 hours immediately prior to application.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS

- A. Concrete shall be 3000 psi mix from an approved batch plant using Portland cement ASTM C150-67, Type 1, sand ASTM C33-67 and coarse aggregate ASTM C33-67.
- B. Expansion joint material for joints shall conform to the requirements of AASHTO M-173. All preformed joint fillers shall have a thickness equal to the width of the joint required (1/2-inch minimum) and shall be furnished in lengths equal to the widths of the slab in which they are to be installed. The upper surface shall be 1/2-inch below the surface of the slab.
- C. Curing materials shall be burlap cloth conforming To AASHTO B-182; waterproof, polyethylene film; or liquid curing compounds conforming to AASHTO M-148 for Type 2 (white pigmented).

### PART 3 - EXECUTION

#### 3.1 CONCRETE CURBS

- A. The curbs shall be installed as detailed on the Drawings.
- B. The subgrade shall be thoroughly compacted and finished to a smooth, firm surface, and shall be moist at the time the concrete is placed. Any concrete that settles after placement shall be removed and replaced without additional compensation as directed by the owner's representative.
- C. Forms shall be of wood or metal and of a depth equal to the thickness of the concrete course. They shall be free from warp, and of sufficient strength, when staked, to hold the alignment

during the concrete placing and finishing operations. All forms shall be cleaned and oiled each time they are used, before concrete is placed against them. Flexible or curved form shall be used on curves as necessary in order to prevent a chord effect in the alignment of the finished work.

- D. The concrete shall be batched and mixed in an approved batch plant and transported to the job site in a truck mixer. Unless otherwise indicated on the plan, concrete curbs, gutters, and curb and gutters shall be constructed uniform section ten feet in length, except where shorter sections are necessary for closures; but no section shall be less than 4 feet in length. The sections shall be separated by sheet steel templates or dividing plates set normal to the face and top of the curb. The plates shall be carefully set during the placing of the concrete and allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place.
- E. Concrete shall be deposited in the forms in such manner that the forms will not be displaced out of grade or alignment. During the placing operations, the concrete shall be spaded or vibrated through out the entire mass and especially against the forms and points. The surface of the concrete shall be tamped, floated, troweled, roomed, corners edged, and finished to the typical section, lines, and grades as soon as practical after the placing of the concrete. The forms shall be left in place until the concrete has set sufficiently that their removal will not injure the concrete.
- F. The curb shall be rubbed with a brush and water to leave a smooth finish free of voids and honeycomb.
- G. The contractor shall pay particular attention to the alignment of curbs on tangents and maintain a smooth radius on curves.
- H. The contractor shall remove any curb that is cracked, settled, honeycombed, or in poor alignment or elevation as determined by the owner's representative.
- I. The contractor shall backfill all curbs with clean topsoil, smooth, free of clogs or debris. The contractor shall fine-grade the backfill to top of curb elevation, ready for placing. The contractor shall replace all curb that is damaged or mud stained beyond cleaning. All curbs shall be left clean and shall present a neat appearance after the back-filling operation.
- J. Preformed expansion joints 3/4 inch thick, extending the full depth of the concrete slab, shall be constructed at the locations indicated on the plans and at other locations as follows:
  - 1. Transverse expansion joints shall be placed at intervals of not more than 100 feet in all new concrete pavement, sidewalk and curb and gutter.
- K. Contraction joints for concrete curbing shall be placed not the exceed 10 feet o/c, by scoring after loading operations are completed. Contraction joints shall be 1 inch deep by 1/2 inch wide and shall be edged and finished smooth and true to line.
- L. As soon as the concrete curb has hardened sufficiently, the forms for the exposed surfaces shall be removed and the concrete for the curb face and top shall be floated and troweled as necessary to provide a smooth uniform finish. Templates shall be left in place a sufficient length of time to prevent bonding at the joint.
- M. After the surface of the gutter has been properly shaped and prepared and the water sheen has disappeared, the final finish shall be by brooming. Brooming shall be transverse to the line of traffic. All joints shall be in a vertical plane perpendicular to the curb face. Joints shall be clean with corners well rounded. All corners shall be edged to conform to the typical cross section. Tool marks shall be eliminated.
- N. Concrete curb shall be backfilled within 48 hours after pouring.

END OF SECTION 32 16 13

## SECTION 32 17 23 - PAVEMENT MARKINGS

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. The Drawings and provisions of the General Conditions, Supplemental Conditions, and Division 1 are included as part of this Section as though bound here.

#### 1.02 RELATED REQUIREMENTS

- A. The General Provisions of Division 1 shall govern this section.
- B. Construction drawings.
- C. Section 32 11 26 - Bituminous Concrete Paving.

#### 1.03 DESCRIPTION OF WORK

- A. Extent of traffic stripe painting is shown on the drawings.
- B. All parking stalls, centerline of entrance drives and other markings as shown on the drawings.
- C. All handicap symbols, directional arrows, turn symbols, stop and yield symbols, no parking stripping, as required for traffic control, are a part of this specification.
- D. All work and materials shall comply with appropriate department of transportation standard specifications, latest edition.

#### 1.04 JOB CONDITIONS

- A. Traffic painting shall be applied only when ambient temperature is above 50 degrees F. and when temperature has not been below 35 degrees F. for 12 hours immediately prior to application. Do not apply when pavement is wet, unclean, or damaged.

### PART 2 - PRODUCTS

#### 2.01 PAINT

- A. Paint shall be "white" traffic stripe suitable for traffic line marking on highways with composition conforming to appropriate department of transportation standard specifications; however, all sections related to pavement shall be excluded.
- B. Paint color for fire lanes and for handicap symbols shall be as per local codes. All paint used shall be suitable for traffic line marking and shall conform to appropriate department of transportation standard specifications.

### PART 3 - EXECUTION

#### 3.01 PARKING LOT STRIPE PAINTING

- A. All parking stalls and centerline striping shall be 4" wide with a wet film thickness of 0.015 inches.
- B. The paint shall dry to touch within 15 minutes, shall dry to no pick-up within 30 minutes when tested in accordance with ASTM C-711. The color after drying shall be pure flat white, free from tint, furnishing the maximum amount capacity for both daylight and artificial light.

- C. The contractor shall certify via letter to the engineer that the paint and execution of work complies with the appropriate North Carolina Department of Transportation standard specifications.

END OF SECTION 32 17 23

## SECTION 32 18 23.26 NATURAL ATHLETIC FIELD TURF

### PART 1 - GENERAL

#### 1.1. RELATED DOCUMENTS

- A. The provisions of the Contract Documents apply to the work of this Section.

#### 1.2. SUMMARY

- A. This Section includes the following:
1. Fine grading and preparing athletic fields
  2. Topsoil Placement
  3. Soil amendments
  4. Fertilizers
  5. Seeding

#### 1.3. DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.  
B. Athletic Fields: All areas labeled on the construction drawings as Softball Field.

#### 1.4. SUBMITTALS

- A. Certification by product manufacturer that the following products supplied comply with requirements:
1. Seed
    - a. Blue Tag Certification by the North Carolina Crop Improvement Association, for the seed.
  2. Infield Mix
    - a. If Owner selects infield mix for Softball / Baseball Fields, provide sample of mix or product specification sheet for approval prior to purchase or installation.
  3. Field Seeding Schedule
    - a. Contractor shall submit field schedule to Owner and Owner's Representative for review and approval.
- B. Installers Qualifications
1. Provide a licensed landscape contractor with a list of at least 3 similar past projects.
- C. Topsoil Amendment Plan.
1. Provide copies of all topsoil testing reports.
  2. Provide list of amendments proposed for topsoil, including application rates.
- D. As-built plan for subgrade at a 25 by 25-foot grid after laser grading is completed.  
E. As-built plan for topsoil at a 10 by 10-foot grid after laser grading is completed.

#### 1.5. QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer, who has successfully completed lawn and turf establishment projects similar in size and complexity to this project. The installer's primary business (defined as a minimum of 60 percent of total billings) shall be establishment of lawns and turf.

- B. Core and Soil Analysis: Core fields including over run areas – one core per 5,000 SF, to ensure required depth of Topsoil and chemical composition. (Coring of the Fields shall be witnessed by the Owner's Third Party Inspection representative). The placement of seed operations shall not commence until the requirements of Section 2.1 and Section 3.3 have been verified through the Core and Soil Analysis Quality Assurance.

1.6. DELIVERY, STORAGE, AND HANDLING

- A. Seed: Deliver, store and handle seed according to the requirements of the supplier's specifications. Do not store in wet or damp location nor in direct sunlight.

1.7. COORDINATION AND SCHEDULING

- A. Planting Season: Seed between April 15 and September 15 unless otherwise approved by Owner or Owner's representative
- B. Weather Limitations: Proceed with planting only when existing and forecast weather conditions are suitable for work.
- C. Athletic Field Planting Schedule:
  - 1. For all Athletic Fields, the Contractor shall have topsoil and seed placed and grown in sufficient for play on fields prior to Owner acceptance of fields.
- D. Athletic Field Inspections: The Owner's Representative will provide the following Athletic Field inspections for the Owner:
  - 1. Site Inspection by Owner or Owner's Representative of topsoiled and seeded Athletic Fields within 1 week after installation.
  - 2. Seeded Athletic Field acceptance inspection as of \_\_\_\_\_date.
  - 3. The Contractor shall be responsible for the cost of additional Athletic Field inspections by the Owner's Representative.

1.8. LIMITS OF SEEDING

- A. Spread topsoil and seed all Athletic Field areas in locations shown on plans.

1.9. PAYMENT PROCEDURES FOR ATHLETIC FIELD TURF

- A. Establish a line item in the Schedule of Values for Athletic Field Turf Maintenance. This line item shall represent a minimum of 40 percent of the total value of the athletic field turf seeding for the project.
- B. Athletic Field Turf maintenance will be paid on a monthly basis, following the satisfactory maintenance of the athletic field turf.

PART 2 - PRODUCTS

2.1. TOPSOIL

- A. Topsoil: ASTM D 5268, pH range of 6.0 to 7.0, a minimum of 4 percent organic material content (by dry weight); free of stones 1/2 inch or larger in any dimension and other extraneous materials harmful to plant growth.
  - 1. Topsoil Source: Reuse surface soil stockpiled on-site to the extent practical. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface

soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

- a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from agricultural land, bogs or marshes.
- B. Have topsoil tested by a certified soil testing laboratory to determine the suitability for growing turf grass lawns. Test results in the following ranges are considered acceptable:
  1. pH Range: 6.0 to 7.0
  2. Organic Matter: > 4%
  3. Magnesium: 60 to 450 ppm
  4. Calcium: 400 to 4,000 ppm
  5. Potassium: 91 to 250 ppm
  6. Phosphorus: 30 to 50 ppm
  7. Soluble Salts: not to exceed 900 ppm
- C. If the soil test results do not fall within the acceptable ranges, add amendments to topsoil as recommended by the soil testing laboratory for turf grass lawns as necessary to meet these requirements.
- D. After soil amendments have been added, have topsoil re-tested by a certified soil testing laboratory and provide the results to the Owner's Representative to verify compliance with the topsoil requirements of this Section.

## 2.2. INORGANIC SOIL AMENDMENTS

- A. If the topsoil analysis indicates the need for inorganic soil amendments, the following standards apply:
- B. Lime: ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:
  1. Class: Class 0, with a minimum 95 percent passing through No. 8 (2.36-mm) sieve and a minimum 55 percent passing through No. 60 (0.25-mm) sieve.
  2. Provide lime in the form of dolomitic limestone.
- C. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum 99 percent passing through No. 6 (3.35-mm) sieve and a maximum 10 percent passing through No. 40 (0.425-mm) sieve.
- D. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- E. Aluminum Sulfate: Commercial grade, unadulterated.
- F. Perlite: Horticultural perlite, soil amendment grade.
- G. Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate.
- H. Sand: Clean, washed, natural or manufactured, free of toxic materials.
- I. Diatomaceous Earth: Calcined, diatomaceous earth, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
- J. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.



## 2.3. ORGANIC SOIL AMENDMENTS

- A. If the topsoil analysis indicates the need for organic soil amendments, the following standards apply:
  - 1. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8.0; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch (19-mm) sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
    - a. Organic Matter Content: 50 percent of dry weight.
    - b. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source -separated or composted mixed solid waste.
    - c. Peat: Finely divided or granular texture, with a pH range of 6.0 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water-absorbing capacity of 1,100 to 2,000 percent.
    - d. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture, free of chips, stones, sticks, soil, or toxic materials.
    - e. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

## 2.4. HERBICIDES

- A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

## 2.5. FERTILIZER

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast-and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
  - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in topsoil analysis reports from a qualified soil-testing agency.
  - 2. Minimum Composition: No less than 1 lb/1,000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

## 2.6. TURFGRASS SEED

- A. All seed shall be Blue Tag certified by the North Carolina Crop Improvement Association.

## 2.7. MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew-and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

- B. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic; free of plant-growth or germination inhibitors; with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

2.8. EROSION-CONTROL MATERIALS

- A. Erosion-Control Fiber Mesh: Biodegradable twisted jute or spun-coir mesh, a minimum of 0.92 lb/sq. yd. (0.5 kg/sq. m) with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

PART 3 - EXECUTION

3.1. EXAMINATION

- A. Examine areas to receive athletic field turf for compliance with requirements and for conditions affecting performance of the Work. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2. PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
- B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3. TOPSOIL PLACEMENT FOR ATHLETIC FIELDS

- A. Athletic Field Subgrades shall be graded utilizing equipment that has been equipped with a laser –guided grading system. Subgrade tolerance shall be within a tolerance of  $\pm 1/2$  inch when measured with a 10-foot straight-edge. Contractor shall provide Owner's Representative with as-built plan at a 25 by 25-foot grid demonstrating compliance with this requirement. Topsoil shall not be placed until Owner's Representative has reviewed and approved the subgrade as-built.
- B. Limit subgrade preparation to areas that will be planted in the immediate future.
- C. Loosen subgrade to a minimum depth of 4 inches. Remove stones, sticks and roots larger than 1 inch in any dimension from subgrade. Completely remove trash and other extraneous debris from subgrade.
- D. Have topsoil tested by a certified soil testing laboratory to determine the type and quantity of soil amendments necessary.
- E. Sift topsoil with a mechanical screen to remove stones and other objects larger than 1/2 inches in any dimension. Maximum object size for topsoil shall be achieved by sifting, not by hand removal or raking following placement of topsoil.
- F. Mix soil amendments and fertilizers with topsoil at rates required by soil testing. Delay mixing fertilizer if planting does not follow placing of planting soil within 4 days. Either mix soil before spreading or apply soil amendments on surface of spread topsoil and mix thoroughly into top 4 inches (100 mm) of topsoil before planting. After soil amendments have been added, have topsoil re-tested by a certified soil testing laboratory and provide the results to the Owner's Representative to verify compliance with the topsoil requirements of this Section.

- G. Mix lime with dry soil prior to mixing fertilizer.
- H. Spread and lightly compact topsoil to a minimum depth of 6 inches.
- I. Final topsoil grades shall be obtained by the use of equipment that has been equipped with a laser-guided grading system. Final topsoil grade tolerance shall be  $\pm 1/2$  inch when measured with a 10-foot straight-edge. Ponding areas or localized low spots are not acceptable. Contractor shall provide Owner's Representative with as-built plan at a 10 by 10-foot grid demonstrating compliance with this requirement. Seed shall not be placed until Owner's Representative has reviewed and approved the topsoil as-built.

3.4. SEEDING ATHLETIC FIELDS

- A. Apply seed within 24 hours of stripping. Do not apply seed outside of seeding timeline or if ground is frozen.
- B. Saturate seed with fine water spray within 2 hours of planting. Water daily or more frequently as necessary to maintain moist soil to a minimum depth of 4 inches below surface. Do not wash seed away with heavy spray or by applying water rapidly to area.
- C. Avoid creating rills and erosion with watering.

3.5. MAINTENANCE OF NEW ATHLETIC FIELD TURF

- A. Begin maintenance of athletic field turf immediately after each area is established and continue until acceptance by Owner. Pre and Post emergent follow seeding specifications in Section 32 92 19.
- B. Maintain and establish athletic field turf by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and mulch to produce a uniformly smooth athletic field surface.
  - 1. Replant bare areas with same materials.
  - 2. Replace disturbed mulch.
- C. Watering: Provide and maintain temporary hoses, and lawn-watering equipment to convey water from a water source to keep athletic field turf uniformly moist to a depth of 4 inches.
  - 1. Provide a source of water for irrigation. Utilize temporary irrigation meters, a well or water trucks as necessary for the water source.
  - 2. Water seeded areas per the requirements of the grower. Maintain moist soil to a depth of at least 4 inches.
- D. At a minimum, the following fertilizer applications are required: **The Owner shall be notified in writing ten days prior to the fertilizer application date. Contractor to provide written verification of the date and that the listed quantities of fertilizer and lime have been applied to the areas listed below.**
  - 1. Provide Spring and Fall fertilization per soil testing results and supplier recommended rates over all seeded athletic field areas.
  - 2. Provide written acknowledgement that this requirement has been met prior to requesting Substantial Completion.
  - 3. If the athletic fields are not constructed by the dates specified by supplier, Owner, or Owner's Representative, the Contractor shall still be responsible for providing fertilizer applications in accordance with the above seasons and rates.

- E. Mow athletic field turf as soon as there is enough top growth to cut with mower set at indicated height. Repeat mowing as required to maintain indicated height without cutting more than 40 percent of the grass height (minimum of 3 mowings). Remove no more than 40 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain following grass height:
  - 1. Mow grass to a finished height of 2 to 3 inches high or as otherwise recommended by seed supplier.
- F. Provide at least a single application of pre-emergent herbicide to Athletic Field turf between February 15 and April 15. Provide written acknowledgement that this requirement has been met prior to requesting Substantial Completion.

3.6. SATISFACTORY ATHLETIC FIELD TURF

- A. Athletic field turf shall be considered satisfactory/acceptable upon written notification by the Owner's Representative, provided requirements, including maintenance, have been met and a healthy, well rooted, even colored, uniform, viable, and close stand of grass is established, free of weeds, bare spots exceeding 5 by 5 inches, and surface irregularities.
- B. (Intentionally left blank.)
- C. Replant athletic field turf that does not meet requirements and continue maintenance until they are satisfactory/acceptable as verified by the Owner or the Owner's Representative.
- D. Athletic field surfaces shall be free of irregularities and shall have a surface smoothness within a tolerance of  $\pm 1/2$  inch as measured with a 10-foot straightedge. Ponding areas or localized low spots are not acceptable. Tripping hazards are not acceptable.
- E. Continue to replant and maintain, including watering, unsatisfactory/unacceptable athletic field turf until acceptance is obtained. Warranties for each athletic field turf area shall begin at the time of acceptance, as verified by the Owner via the Owner's Representative.
- F. Substantial Completion of the rest of the project shall not relieve the Contractor of their responsibilities to establish and maintain acceptable Athletic Field turf in accordance with this Section.

3.7. CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by lawn work from sidewalks and paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto surface of roads, walks, or other paved areas.
- B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades throughout maintenance period until lawn is established.

**END OF SECTION 32 18 23.26**

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## SECTION 32 31 00 - FENCES AND GATES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Swing gates.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include manufacturer's data sheets on each product to be used including, but not limited to construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
    - a. Preparation instructions and recommendations
    - b. Storage and handling requirements and recommendations.
    - c. Installation methods
    - d. Gate, gate posts, rails, and fittings, hardware, and locking mechanism.
    - e. Reinforcements, gate wheels or cane bolt mechanism, and any other attachments or operations information.
    - f. Accessories, including locks, signs, reflective paint or signs
- B. Shop Drawings: For each type of fence and gate assembly.
  - 1. Include plans, elevations, sections, details, and attachments to other work; hardware anchorage, and post foundation section with dimensions.
  - 2. Include accessories, hardware, gate operation, and operational clearances.
  - 3. Include schedule of components
  - 4. Include color / finishes schedule and samples for Owner approval.
  - 5. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions. (only if motorized gate is proposed).
  - 6. Wiring Diagrams: For power, signal, and control wiring.(only if motorized gate is proposed).
- C. Delegated-Design Submittal: For structural performance of gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **professional engineer**

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum five years documented experience
- B. Installer Qualifications: Installers experienced with type of construction involved and materials and techniques specified.
- C. Product Data Sheet / Product Certificates: For each type of gate.
- D. Product Test Reports: For framework strength according to ASTM F 2656, for tests performed by **manufacturer and witnessed by a qualified testing agency**.

1.6 EMERGENCY ACCESS REQUIREMENTS

- A. Emergency Access Requirements: Campus shall be accessible to emergency responders. Manual Gates shall be fitted with a lock box or other locking mechanism acceptable to the emergency responders' requirements. If the gate opening method is automatic, approval by the local emergency responders is required prior to order and installation of the gates/ opening mechanism.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Upon receipt at the job site, all materials shall be checked to ensure that no damage occurred during shipping or handling.
- B. Materials shall be stored in such a manner to ensure proper ventilation and drainage, and be protected against damage, weather, vandalism, and theft.

1.8 FIELD CONDITIONS

- A. Field Measurements: Verify layout information for gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements. Notify Owner's Representative of any discrepancy prior to order and installation.
- B. Maintain environmental conditions as specified by manufacturer. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.9 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gate operators and locking mechanisms to include in emergency, operation, and maintenance manuals.
- B. Provide any manufacturer's warranty transferable to the Owner.

1.10 WARRANTY

- A. Special Warranty: **Installer agrees** to repair or replace components of gates that fail in materials or workmanship within specified warranty period.



1. Failures include, but are not limited to, the following:
  - a. Failure to comply with performance requirements.
  - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
  - c. Faulty operation of gates and/or controls (if automated).
2. Warranty Period: **Two (2)** years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design gate frameworks if contractor does not source gate from manufacturer with quality assurance documents identified in Part 1.
- B. Provide any delegated design required for post footing if not otherwise provided by gate manufacturer.
- C. Metal Protection: Gates, framework, hardware, openers, locking mechanisms, and accessories shall have protective coating. Protection method shall be per manufacturer's recommendations and suitable to prevent corrosion, chipping, or other surface or structural damage to gate.
- D. Structural Performance: Gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to **ASCE/SEI 7**.
  1. Design Wind Load: **120 mph**.
    - a. Heavy Industrial Grade Gate including posts, framework, rails/ pickets, mounting and locking accessories
    - b. Minimum Post Size: Steel Post 4" by 4" by 11 gauge with post cap.
    - c. Steel (ASTM A924 / A924M) for tubular pickets, rails, and posts shall have minimum yield strength of 45,000 psi unless anti-ram requirements require greater minimum yield strength
    - d. Height as recommended by manufacturer, but not to exceed 4' height.
    - e. Compliance with ASTM F2656

### 2.2 SWING GATES

- A. General: ASTM F 2656 for gate posts and **single and double** swing gate types.
  1. Gate Leaf Width: **Refer to plan and field conditions for dimensions of each gate; gate shall cross full width of access road; contractor may provide double gates if span is too long to meet other specifications. Shop drawings to identify gate leaf width for each location.**
- B. Hardware:

1. Hinges: **360-degree inward and outward** swing preferred. Locking mechanism and other specifications may prevent inward and outward swing. Contractor shall provide hinge degree with shop drawings.
2. Latch: Permitting operation from both sides of gate **with provision for locking accessible from both sides of gate.**
3. Lock: **Manufacturer's recommendation and as otherwise acceptable to emergency responders. Contractor shall provide latch and lock unless otherwise directed by Owner.**

## 2.3 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.
- B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

## 2.4 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for a **certified survey of property lines and legal boundaries**, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
  1. Do not begin installation before final grading and access road construction is completed unless otherwise permitted by Owner or Owner's representative.
  2. Gates shall be constructed for final site conditions of asphalt and surrounding finished grade. Contractor shall construct so no gate drags or sags at final site acceptance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

## 2.5 PREPARATION

- A. Stake locations of gates, and posts. Do not place gates or posts to obstruct drivers' views of the access road or intersecting roads/ drives.
- B. Remove or correct any surface irregularities in surrounding grade or asphalt that may interfere with the installation and / or operation of the gate.

## 2.6 GATE INSTALLATION

- A. Install in accordance with manufacturer's instructions and avoid any installation practices that could void the manufacturer's warranty.
- B. Install gates and posts according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using

tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

- C. Do not install any gates or posts outside of the property boundary or in any adjacent right of way.
- D. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- E. Post Setting: Set posts **in concrete** at indicated spacing into firm, undisturbed soil.
  - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
  - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
    - a. Concealed Concrete: Place top of concrete **as recommended by manufacturer or as indicated in drawings** to allow covering with surface material.
    - b. Posts Set into Sleeves in Concrete: If using steel pipe sleeves preset and anchored into concrete for installing posts: After posts are inserted into sleeves, fill annular space between post and sleeve with **nonshrink, nonmetallic grout**, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
    - c. Posts Set into Holes in Concrete: Form or core drill holes not less than 5 inches deep and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with **nonshrink, nonmetallic grout** mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.

## 2.7 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Erection Tolerances
  - 1. Maximum variation from plumb: 1/4 inch
  - 2. Maximum offset from indicated position: 1 inch
- C. If gate is automated, lubricate hardware and other moving parts.

## 2.8 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair, or replace any damaged products before Substantial Completion. Match touchup paint color to gate finish.

2.9 DEMONSTRATION

- A. If automated gate opener provided, engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 32 31 00

## SECTION 32 31 13 – CHAIN LINK DENCES AND GATES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Chain-link fences.
  - 2. Swing gates.
  - 3. Horizontal-slide gates.
  - 4. Privacy slats.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
    - a. Fence and gate posts, rails, and fittings.
    - b. Chain-link fabric, reinforcements, and attachments.
    - c. Accessories:
    - d. Gates and hardware.
- B. Shop Drawings: For each type of fence and gate assembly.
  - 1. Include plans, elevations, sections, details, and attachments to other work.
  - 2. Include accessories, hardware, gate operation, and operational clearances.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For framework strength according to ASTM F 1043, for tests performed by **manufacturer and witnessed by a qualified testing agency**, as necessary for any materials not otherwise identified in these specifications but proposed in the shop drawings.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

#### 1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- B. Emergency Access Requirements: According to requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.

#### 1.6 FIELD CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

#### 1.7 WARRANTY

- A. Special Warranty: **Installer agrees** to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
  1. Failures include, but are not limited to, the following:
    - a. Failure to comply with performance requirements.
    - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
    - c. Faulty operation of gate operators and controls.
  2. Warranty Period: **Two (2)** years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design chain-link fence and gate frameworks.
- B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to **ASCE/SEI 7**.
  1. Design Wind Load: **120 mph**. or as otherwise dictated by building code.
    - a. Minimum Post Size: Determine according to ASTM F 1043 for post spacing not to exceed **12 feet** for Material **Group IA, ASTM F 1043, Schedule 40 steel pipe**; follow unless otherwise specified on plans
    - b. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified.
- C. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.

## 2.2 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:
1. Fabric Height: **As indicated on Drawings.**
  2. Steel Wire for Fabric: **Wire diameter of 0.192 inch**
    - a. Mesh Size: 2 inches
    - b. Polymer-Coated Fabric: ASTM F 668, **Class 2a** over **aluminum**-coated steel wire.
      - 1) Color: **Black**, according to ASTM F 934.
    - c. Coat selvage ends of metallic-coated fabric before the weaving process with manufacturer's standard clear protective coating.

## 2.3 FENCE FRAMEWORK

- A. Posts and Rails: ASTM F 1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 based on the following (unless otherwise specified all diameter references outside diameter (OD)):
1. Fence Height: **As indicated on Drawings.**
  2. Light-Industrial-Strength Material: **Group IC-L, round steel pipe, electric-resistance-welded pipe.**
    - a. Line Post: **1.9 inches in diameter.**
    - b. End, Corner, and Pull Posts: **2.375 inches.**
  3. Heavy-Industrial-Strnght Matrial: Group IA, round steel pipe, Schedule 40.
    - a. Line Post: 2.375 inches in diameter
    - b. End, Corner, and Pull Posts: 2.875 inches in diameter
  4. Horizontal Framework Members: **top and bottom** rails according to ASTM F 1043.
    - a. Top Rail: **1.66 inches in diameter.**
  5. Brace Rails: ASTM F 1043; **1 -5/8 inches in diameter**
  6. Metallic Coating for Steel Framework:
    - a. Type A: Not less than minimum 2.0-oz./sq. ft. average zinc coating according to ASTM A 123/A 123M or 4.0-oz./sq. ft. zinc coating according to ASTM A 653/A 653M.
    - b. Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
    - c. External, Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil-thick, zinc-pigmented coating.
    - d. Type C: Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. coating.
    - e. Coatings: Any coating above.
  7. Polymer coating over metallic coating.

- a. Color: **Black or as otherwise specified by Owner or Owner's Representative**, according to ASTM F 934.

## 2.4 TENSION WIRE

- A. Metallic-Coated Steel Wire: 0.177-inch-diameter, marcelled tension wire according to ASTM A 817 or ASTM A 824, with the following metallic coating:
  1. Type II: Zinc coated (galvanized) by **electrolytic** process, with the following minimum coating weight:
    - a. Matching chain-link fabric coating weight.
- B. Polymer-Coated Steel Wire: **0.148-inch**-diameter, tension wire according to ASTM F 1664, **Class 2b** over **aluminum**-coated steel wire.
  1. Color: **Black**, according to ASTM F 934.

## 2.5 SWING GATES

- A. General: ASTM F 900 for gate posts and **single and double** swing gate types.
  1. Gate Leaf Width: **As indicated; 4' wide opening unless otherwise specified on plans; gate shall swing away from field or playing surface**
  2. Framework Member Sizes and Strength: Based on gate fabric height **as indicated.; tennis court gates min. 1-5/8 inches diameter**
- B. Pipe and Tubing:
  1. Zinc-Coated Steel: ASTM F 1043 and ASTM F 1083; **manufacturer's standard protective coating and finish.**
  2. Aluminum: ASTM B 429/B 429M; **manufacturer's standard** finish.
  3. Gate Posts: **Round tubular steel.**
  4. Gate Frames and Bracing: **Round tubular steel.**
- C. Frame Corner Construction: **Welded.**
- D. Hardware:
  1. Hinges: **360-degree inward and outward** swing.
  2. Panic Hardware not include in these specifications (refer to architectural hardware plans and specifications; panic hardware provided on any gate providing egress from a building
  3. Latch: Permitting operation from both sides of gate **with provision for padlocking accessible from both sides of gate.**
  4. Lock: **Manufacturer's standard** internal device.
  5. Padlock and Chain: Provided by Owner, however; Contractor shall coordinate lock type with Owner to be certain gate can accept the lock.
  6. Closer: **Manufacturer's standard.**

## 2.6 FITTINGS

- A. Provide fittings according to ASTM F 626.



- B. Post Caps: Provide for each post.
  - 1. Provide line post caps with loop to receive tension wire or top rail.
- C. Rail and Brace Ends: For each gate, corner, pull, and end post.
- D. Rail Fittings: Provide the following:
  - 1. Top Rail Sleeves: **Pressed-steel or round-steel tubing** not less than 6 inches long.
  - 2. Rail Clamps: Line and corner boulevard clamps for connecting **bottom** rails to posts.
- E. Tension and Brace Bands: **Pressed steel**.
- F. Tension Bars: **Steel**, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: **Steel, hot-dip galvanized after threading** rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: According to ASTM F 626.
  - 1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:
    - a. Hot-Dip Galvanized Steel: **0.106-inch**-diameter wire; **galvanized coating thickness matching coating thickness of chain-link fence fabric**.
    - b. Aluminum: ASTM B 211; Alloy 1350-H19; **0.148-inch**-diameter, mill-finished wire.
- I. Finish:
  - 1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz./sq. ft. of zinc.
    - a. Polymer coating over metallic coating.
  - 2. Aluminum: Mill finish.
- J. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.
- K. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

## 2.7 GROUNDING MATERIALS

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches.

2.8 PRIVACY SLATS

A. Comply with ASTM F3000 / F3000M – 13 (2018) “Standard Specification for Polymer Privacy Insert Slats for Chain Link Fabric and Privacy Chain Link Fabric Manufactured Containing Pre-Installed Privacy Slats”. Verify with Owner if any fence beyond dumpster fence needs privacy slats.

B. This specification covers polymer privacy insert slats designed for insertion into chain link fabric after the chain link fence installation and privacy chain fabric having slats pre-inserted into chain link mesh during the chain link weaving process.

1. Type P-V consists of polyethylene privacy insert slats hand inserted vertically into standard mesh chain link fabric after the fence installation.
2. Type P-D consists of polyethylene privacy insert slats hand woven diagonally into standard mesh chain link fabric after the fence installation.
3. Type F-VDH consists of modified fiberglass privacy insert slats hand woven, vertically, diagonally, or horizontally into standard mesh chain link fabric after the fence installation.
4. Type PI-V consists of privacy chain link fabric containing vertical high-density polyethylene privacy slats pre-inserted into the chain link mesh during the chain link weaving process. Style 1a: Wider, 2 3/8 in. to 3 in. slats, pre-inserted into specially designed larger mesh. Style 1b: Type P-V friction fit slats pre-inserted into standard 2in. chain link mesh.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for a **certified survey of property lines and legal boundaries**, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.

1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

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

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

### 3.3 CHAIN-LINK FENCE INSTALLATION

- A. Install chain-link fencing according to ASTM F 567 and more stringent requirements specified.
  - 1. Install fencing on established boundary lines inside property line. Only applies if Owner adds fencing beyond what plans identify.
- B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- C. Post Setting: Set posts **in concrete** at indicated spacing into firm, undisturbed soil.
  - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
  - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
    - a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.
    - b. Concealed Concrete: Place top of concrete **as indicated on Drawings** to allow covering with surface material.
    - c. Posts Set into Sleeves in Concrete: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with **nonshrink, nonmetallic grout**, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
    - d. Posts Set into Holes in Concrete: Form or core drill holes not less than 5 inches deep and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with **nonshrink, nonmetallic grout** mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
- D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of **15 degrees or more**. For runs exceeding 500 feet, space pull posts an equal distance between corner or end posts.
- E. Line Posts: Space line posts uniformly at **96 inches** o.c.
- F. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
  - 1. Locate horizontal braces at midheight of fabric 72 inches or higher, on fences with top rail. Install so posts are plumb when diagonal rod is under proper tension.
- G. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fence posts. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
  - 1. Extended along **top** and **bottom** of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

2. Extended along top of **extended posts** and top of fence fabric to support barbed tape.
- H. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- I. Intermediate and Bottom Rails: Secure to posts with fittings.
- J. Chain-Link Fabric: Apply fabric to **outside** of enclosing framework. Leave **1-inch** bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- K. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than 15 inches o.c.
- L. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric according to ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
  1. Maximum Spacing: Tie fabric to line posts at 12 inches o.c. and to braces at 24 inches o.c.
- M. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. **Peen ends of bolts or score threads to prevent removal of nuts.**

### 3.4 GATE INSTALLATION

- A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

### 3.5 GROUNDING AND BONDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Fence and Gate Grounding:
  1. Ground for fence and fence posts shall be a separate system from ground for gate and gate posts.
  2. Install ground rods and connections at maximum intervals of **1500 feet**.
  3. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of **750 feet**.
  4. Ground fence on each side of gates and other fence openings.
    - a. Bond metal gates to gate posts.
    - b. Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

- C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of 150 feet on each side of crossing.
- D. Fences Enclosing Electrical Power Distribution Equipment: Ground according to IEEE C2 unless otherwise indicated.
- E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
  - 1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
  - 2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
- F. Connections:
  - 1. Make connections with clean, bare metal at points of contact.
  - 2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
  - 3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
  - 4. Make above-grade ground connections with mechanical fasteners.
  - 5. Make below-grade ground connections with exothermic welds.
  - 6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- G. Bonding to Lightning Protection System: Ground fence and bond fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor according to NFPA 780.
- H. Comply with requirements in Section 264113 "Lightning Protection for Structures."

### 3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **Contractor shall engage** a qualified testing agency to perform tests and provide reports to Owner or Owner's Representative
- B. Grounding Tests: Comply with requirements in Section 264113 "Lightning Protection for Structures."
- C. Prepare test reports.

3.7 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 323113

## SECTION 32 91 13 - SOIL PREPARATION

### PART 1 - GENERAL

#### SCOPE

The work under this section shall consist of providing all work, materials, labor, equipment and supervision necessary to provide and prepare soil for seeding, sodding, and landscape planting. Included are the following topics:

#### 1.01 SECTION INCLUDES

##### A. PART 1 - GENERAL

- Scope
- Related Sections
- Unit Prices
- Definitions
- Regulatory Requirements
- Reference Standards
- Submittals
- Quality Assurance

##### B. PART 2 - MATERIALS

- Topsoil
- Soil Amendments
- Fertilizer

##### C. PART 3 - EXECUTION

- Subgrade Soil Preparation
- Placing Topsoil
- Organic Soil Amendments and pH Adjustment
- Fertilizer

#### 1.02 RELATED SECTIONS

- A. Section 31 22 00 – Grading: Topsoil material.
- B. Section 31 22 00 – Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this section.
- C. Section 31 23 23 – Fill and Backfill: Topsoil material.

#### 1.03 UNIT PRICES - MEASUREMENT AND PAYMENT

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Topsoil:
  - 1. Basis of Measurement: By the cubic yard.
  - 2. Basis of Payment: Includes topsoil, placing topsoil.

#### 1.04 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than sizes indicated diameter and depth recommended by

ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1.

- C. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.
- D. Finish Grade: Elevation of finished surface of planting soil.
- E. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- F. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant or desiccant.
- G. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals or people. These include insects, mites, grubs, mollusks (snails or slugs), rodents, unwanted plants (weeds), fungi, bacteria and viruses.
- H. Planting Soil: The following types of standardized topsoil: existing in-place surface topsoil, surface soil modified to become topsoil imported topsoil, or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- I. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill immediately beneath planting soil.
- J. Weeds: Include but are not limited to: Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

#### 1.05 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.

#### 1.06 REFERENCE STANDARDS

- A. ASTM D5268-07 Standard Specification for Topsoil Used for Landscaping
- B. USDA Agricultural Handbook No. 60 Diagnosis and Improvement of Saline and Alkali Soils
- C. American Nursery and Landscape Association

#### 1.07 DELIVERY, STORAGE, AND HANDLING



- A. Packaged Materials: Deliver packaged materials in original, unopened, labeled, and undamaged containers showing weight, name of manufacturer and indication of conformance with state and federal laws (as applicable). Store and handle materials according to manufacturer's and supplier's recommendations.
- B. Bulk Materials:
  - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements or on existing turf areas or plants.
  - 2. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems or walkways.
  - 3. Accompany each delivery of bulk fertilizers, lime and/or soil amendments with appropriate certificates. Provide copies of these to the Owner/Architect upon request.
- C. Pesticides:
  - 1. Handle all pesticides in accordance with federal, state and local rules and regulations.
  - 2. Do not store these products near structures, utilities, walkways and pavements or on existing turf areas or plants.

#### 1.08 SUBMITTALS

- A. Soil Testing: For existing soil in representative landscape areas and turf areas, including but not limited to athletic fields, provide testing results and analysis or recommendations from an independent third party testing laboratory to correct deficiencies or problematic soil conditions.
- B. Material Test Reports: Provide copies of all quality assurance testing reports for all soils intended for use in planting or turf areas on the site. Reports required for at least: existing surface soil, manufactured soil, imported soil in planting areas and soil intended for use as planting soil (if different than existing surface soil).
- C. Provide product data, including applicable analytical data, for soil amendments including but not limited to:
  - Peat products
  - Lime
  - Fertilizer

## 1.09 QUALITY ASSURANCE

The Contractor shall retain the services of an independent soil testing laboratory to process soil sampling, testing and analysis of salvaged and imported soil and amendments as required by this section and elsewhere in the Contract Documents. The materials testing consulting Architect/Engineer shall be subject to approval by the Owner.

Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

Soil Analysis: A soil test and analysis of a wide representation of soils through out the intended planting and turf areas. Once the site is rough graded, contractor shall collect and test each unamended soil type and each selected location, and furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil. The test results should also include the soil-testing laboratory's recommendations for any corrective measures needed to grow healthy, thriving specified plant material or turf on the site.

Testing methods and written recommendations shall comply with USDA's Handbook No. 60.

The soil-testing laboratory shall be given samples with information including depth and location, and number of samples taken over the entire site. If the Owner or Architect chose, the contractor may be required to have the soil-testing laboratory oversee the soil sampling. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.

Report suitability of and recommended alterations of tested soil for healthy, thriving plant & turf growth.

Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.

Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

Fertilizer shall be delivered to the site in original, sealed containers, and stored in a waterproof space. Containers shall bear the manufacturer's name, analysis, trademark and guarantee unless otherwise approved by Owner or Architect.

Collection of soil specimens shall be complete in accordance with accepted practices, and shall be subject to approval by the Owner.

## PART 2 - PRODUCTS

## 2.01 TOPSOIL

Clean salvaged or imported material capable of passing the 1" sieve and meeting the requirements of Section 625.2(1) of the Standard Specifications for Highway Construction. The material shall be free of rocks, gravel, wood, debris, and of noxious weeds and their seeds.

## 2.02 SOIL AMENDMENTS

Soil amendments acceptable as part of a backfill mix (if appropriate according to soils testing report) include but not limited to:

- Peat Moss - Type 1 sphagnum, weed and seed free, 3.1-5.0 pH
- Sedge Peat - decomposed peat with no identifiable fibers
- Leaf Compost - screened and free of trash and other debris
- Compost - standard commercial grade compost of sheep or cow manure
- Pine Bark - potting grade pine bark with no particles larger than 1/2" (1.3 cm), less than 10% wood fiber
- Lime: ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:
  - Class: Class T, with a minimum 99 percent passing through No. 8 (2.36-mm) sieve and a minimum 75 percent passing through No. 60 (0.25-mm) sieve.
  - Class: Class O, with a minimum 95 percent passing through No. 8 (2.36-mm) sieve and a minimum 55 percent passing through No. 60 (0.25-mm) (0.25 mm) sieve.
- Provide lime in form of ground dolomitic limestone.
- Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum 99 percent passing through no. 6 (3.35 mm) sieve and a maximum 10 percent passing through No. 40 (0.425 mm) sieve.
- Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- Aluminum Sulfate: Commercial grade, unadulterated.
- Perlite: Horticultural perlite, soil amendment grade.
- Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate with 90 percent passing through No. 50 (0.30 mm) sieve.
- Sand: Clean, washed, natural or manufactured, free of toxic materials.
- Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
- Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

Soil amendments shall be capable of passing the 1" sieve. The material shall be free of rocks, gravel, wood, debris, and of noxious weeds and their seeds. Any soil amendments other than those listed above should be approved by Owner and/or Architect prior to use on site.

## 2.03 FERTILIZER

Use commercially available fertilizer meeting the following requirements: commercial grade complete fertilizer of neutral character, consisting of fast and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the composition as recommended by the findings and recommendations in the soils report.

All fertilizers shall be delivered fully labeled according to applicable regulations, bearing name, trade name or trademark of producer, along with producer's warranty. Application amounts of fertilizer and lime will be governed by the recommendations of the soil test.

### PART 3 - EXECUTION

#### 3.01 SUBGRADE SOIL PREPARATION

Remove or mow all vegetation to a height 3" maximum. Remove all rocks, debris, and litter that will prevent compliance with topsoil and seeding specifications. Final grade area to within 2" of subgrade elevations. Rake, till, or disc the subsoil to a depth of 2"-4" to allow aeration.

#### 3.02 PLACING TOPSOIL

Place topsoil to achieve final grades indicated on the Drawings, allowing for settlement. Place topsoil to the depth shown on the Drawings. If no depth is shown provide a minimum of 4" of topsoil.

Do not apply topsoil to saturated or frozen subgrades.

#### 3.03 ORGANIC SOIL AMENDMENTS AND pH ADJUSTMENT

Provide organic soil amendments and lime as recommended soil analysis. If topsoil has been determined acceptable by a soil test, no amendments are needed.

Uniformly apply organic soil amendments and lime, and incorporate into the top 4"-6" of soil by tilling or discing.

#### 3.04 PRE-EMERGENT HERBICIDE

Pre-emergent herbicides shall be applied in accordance with any local, state, or federal guidelines to control weeds in planting and turf areas.

#### 3.05 FERTILIZER

Fertilizer shall be applied in accordance with the recommendations of the soils test.

END OF SECTION 32 91 13

## SECTION 32 92 00 –PLANTS

### PART 1 - GENERAL

#### SCOPE

These specifications, along with contract drawings and lists of plant materials, apply to those items necessary for and incidental to the preparation, execution, completion and maintenance of the landscape planting activities (excluding turf areas) specified in the contract. The scope includes the planting of trees, shrubs, ground covers, perennials, annuals, and bulbs, and the maintenance activities of fertilizing, pruning and watering.

#### PART 1 - GENERAL

- Scope
- Related Work
- References
- Quality Assurance
- Measurement
- Inspection
- Substitutions
- Delivery, Storage and Handling
- Planting Schedule
- Job Conditions
- Guarantee

#### PART 2 - PRODUCTS

- Materials

#### PART 3 - EXECUTION

- Preparation
- Planting of Trees and Shrubs
- Finishing
- Staking
- Planting of Ground Covers, Perennials, Annuals and Bulbs
- Inspection and Acceptance
- Cleaning
- Pruning
- Maintenance

#### 1.1 RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 32 97 00 – Landscape Maintenance and Extended Warranty  
Section 32 91 13 – Soil Preparation

#### 1.2 REFERENCES

ANSI Z60.1 American Standards for Nursery Stock  
ANSI A300 American National Standard for Tree Care Operations - Tree,  
Shrub and Other Woody Plant Maintenance-Standard Practices

### 1.3 QUALITY ASSURANCE

All plant material shall conform to the *American Standards for Nursery Stock*, unless noted otherwise herein.

All plant material shall be true to the species and variety/hybrid/cultivar specified, and nursery-grown in accordance with good horticultural practices, and under climatic conditions similar to those of the site location. Nursery dug specimens to be replanted shall have been freshly dug and properly prepared for planting.

Trees and shrubs shall be trained in development and appearance as to be superior in form, compactness and symmetry. Trees with multiple leaders, unless specified otherwise, and shrubs with damaged or cut main stem(s), will be rejected.

Trees and shrubs with a damaged, cut or crooked leader, abrasion of bark, sunscald, frost crack, disfiguring knots, insects (including eggs and larvae) or insect damage, cankers/cankorous lesions or fungal mats, mold, prematurely-opened buds, or cuts of limbs over 3/4" (1.9 cm) diameter that are not completely callused will be rejected.

Trees and shrubs shall have healthy, well-developed root systems, and be free from physical damage or other hindrances to healthy growth.

Balled and burlapped plants shall be dug with solid balls of a diameter not less than that recommended by the *American Standards for Nursery Stock*, and of sufficient depth to include both fibrous and feeding roots. Balls shall be securely wrapped with burlap, and tightly bound with rope or twine. No plant shall be bound with rope or wire in such manner as to damage bark or break branches. The root flare should be within the top 2" (5.1 cm) of the soil ball.

Balled and burlapped plants will not be accepted if the ball is dry, cracked, or broken before or during planting.

Containerized plants are to be well-established within the container, with a root system sufficiently developed to retain its shape and hold together when removed from the container. Soil within the container should be held together by the roots, in form and whole. Plants shall not be pot-bound, nor have kinked, circling, or bent roots.

Bare root plants are to have a healthy, well-branched, and adequately spreading root system characteristic of the species.

Herbaceous perennials, annuals and bulbs shall only be supplied from nurseries certified by state plant inspectors. Substitutes or collected material may be used if approved by Owner or Architect/Engineer.

Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed

For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.

Testing methods and written recommendations shall comply with USDA's Handbook No. 60.

The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of [three] [ ] representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.

Report suitability of tested soil for plant growth.

Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.

Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

#### Installer Qualifications:

1. A qualified, State of North Carolina licensed landscape contractor whose work has resulted in successful establishment of exterior plants. Licensed Landscape Contractor must be in compliance with all applicable local, state, and federal regulations and requirements.
2. Installer's Field Supervision: Require landscape installer to maintain an experienced full-time supervisor on project site when planting is in progress.
3. Irrigation Installer: State of North Carolina licensed irrigation contractor.
4. Pesticide Applicator: State of North Carolina licensed applicator of commercial pesticide.

## 1.4 MEASUREMENT

Plants shall conform to the measurements specified within the contract documents. Specified height and spread dimensions will refer to the main body of the plant, and not from branch tip to branch tip. Plants meeting a specified measurement, but judged to lack the balance between height and spread characteristic of the species will be rejected.

Plants shall be measured when branches are in their normal position.

No plant shall be less than the minimum size specified, and no less than fifty (50) percent of the plants shall be as large as the maximum size specified.

Measure trees and shrubs with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.

Containerized shrubs shall be measured by height and width for conformity with the plant list.

Herbaceous perennials shall be measured by pot size, not by top growth.

All other measurements, such as number of canes, ball sizes, and quality designations, shall conform to *American Standards for Nursery Stock*.

## 1.5 INSPECTIONS

Plant materials shall be subject to pre-delivery inspection and approval by the Owner or Architect/Engineer at a nursery or some other site where they are growing, this to judge conformity with specified requirements. Upon securing all plant materials, the Contractor shall submit to Owner a written request for inspection at least five (5) working days prior to the proposed date. After approval by the Owner or Architect/Engineer, the plant is to be tagged for delivery.

Tagged plants are to be inspected on delivery to the project site, and the Owner or Architect/Engineer may reject any specimens no longer meeting the specified standards or that have been damaged in transit.

A representative of the Contractor shall be present at all inspections by the Owner or Architect/Engineer.

## 1.6 SUBSTITUTIONS

The substitution of plant materials is not permitted unless authorized in writing by Owner. If written proof is submitted by the Contractor that a plant of specified species, variety or size is unavailable, consideration will be given towards the nearest available size or variety, or towards an alternate species selection, with a corresponding adjustment of the contract price.

Larger plants than those specified can be used upon approval of the Owner or Architect/Engineer. The use of larger plants shall not increase the contract price. The root ball, root spread and container size of the larger specimen shall be proportionally increased, relative to the specified size.

## 1.7 DELIVERY, STORAGE AND HANDLING



The Contractor is to arrange for the acceptance and unloading of plants at the project site.

All plants are to be labeled by plant name and size. Labels shall be attached securely to all plants, bundles, and containers of plant materials when delivered. Labels shall be durable and legible, with information given in weather-resistant ink or embossed process lettering.

All plant materials, shipments and deliveries shall comply with current state and federal laws and regulations governing the inspection, shipping, selling and handling of plant stock. If required by law or regulation, a certificate of inspection, or a copy thereof, for injurious insects, plant diseases, and other plant pests shall accompany each shipment or delivery of plant material. The certificate shall bear the name(s) and address(es) of the source of the plant stock.

During transport, no plant shall be bound with rope or wire in a manner that damages trunks or breaks branches. Plants shall also not be dragged, lifted or pulled by the trunk, branches or foliage in a damaging way. No plant shall be thrown off of a truck or loader to the ground.

Prior to installation, all plants must be protected from sun and drying winds.

Containerized or balled and burlapped plants not being installed immediately must be kept in a shaded area, well-covered with wood chips, soil, or other approved material, and kept well-watered. Install all plants within three (3) days of delivery.

Cover roots of bare root plants with a moist tarp, burlap, sphagnum moss, or mulch while being transported to, or while being held at the project site. Soak the bare roots overnight in water before planting. Just before planting, extend the roots carefully into a natural position, free of bunching, kinking or circling. Cut back all broken or damaged roots to a point clean and free of rot. No additional root pruning is allowed. Carefully work backfill mix among the roots while simultaneously watering.

Fertilizer shall be delivered to the site in original, sealed containers, and stored in a waterproof space. Containers shall bear the manufacturer's name, analysis, trademark and guarantee as per standards of the North Carolina Department of Agriculture.

## 1.8 PLANTING SCHEDULE

Planting of deciduous, conifers and broadleaf evergreen tree and shrub species shall be completed before winter before first freeze and may resume planting again in spring after last frost.

Tender perennials planting shall be coordinated with and approved by the Owner/Architect prior to installation.

## 1.9 JOB CONDITIONS

Protect all plants, lawns, and grass areas from damage at all times. Damaged plants, lawns or grass areas shall be replaced or treated as required to conform with specifications herein for fresh stock.

Work areas shall be kept clean and orderly during the installation period. Under no condition shall debris from planting activities result in a safety hazard on-site or to adjacent off-site property.

Damage to lawns or grass areas incurred as a result of replacement operations shall be repaired by Contractor at no cost to Owner.

#### A. Warranty

All plants shall be warranted to be in healthy and flourishing condition by after the end of one full growing season.

At any time during the warranty period, the Contractor shall remove or replace, without cost to the Owner, and within a specified planting period, all plants not in a healthy and flourishing condition as determined by the Owner or Architect/Engineer.

Replacement plants shall be subject to the same specified requirements of the contract. The warranty of replacement plants shall extend for one year. If one year warranty ends during a dormant season, the warranty shall extend at least one month into the following growing season (or as otherwise specified by the Owner/Architect). In the event that a replacement plant is not acceptable during, or at the end, of the said warranty extension period, Owner may choose between subsequent replacement or credit for that item.

Include the following remedial actions as a minimum:

Immediately remove dead plants and replace unless required to plant in the succeeding planting season.

Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

A limit of one replacement of each plant will be required except for losses or replacements due to failure to comply with requirements.

Provide extended warranty for period equal to original warranty period, for replaced plant material.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

Plant Materials: A complete list of plant materials, including a schedule of quantities, sizes, quality and source location, shall be included in the contract documents. If discrepancies occur between the printed plant list, and the drawings, notify the Owner/Architect for clarification prior to purchase or installation of these materials.

Owner may request a written list of the proposed sources of nursery stock at the preconstruction meeting. This list may not be added to or otherwise altered without the consent of Owner.

Topsoil: Naturally fertile, agricultural soil, capable of sustaining vigorous growth, of uniform composition throughout, without admixtures of subsoil, free of clay, stones larger than 1" inch diameter, roots, trash and debris of any kind, supplied by Contractor at his/her expense, and subject to approval by the Owner or Architect/Engineer.

Organic Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings. Organic Matter Content: 50 percent of dry weight.

Planting Mixture: Material used in tamping around balls and roots during the planting operation shall be prepared on site.

Ratio of Loose Compost to Topsoil by Volume: 1:4 parts native topsoil from project site to organic compost unless otherwise directed by soil test recommendations. Conform to alternate mixes as specified for beds of certain ornamental plants. All mixing shall be done by mechanical means subject to the approval of the Project Representative or Landscape Architect.

Fertilizer: Granular, non-burning product composed of not less than fifty (50) percent organic slow-acting, guaranteed analysis professional fertilizer. Commercial fertilizer shall conform to North Carolina State Statutes and meet the standards of the North Carolina Department of Agriculture as to registration and labeling. Fertilizer shall be specified in the contract documents as to composition, but is subject to revision to suit project site conditions.

Organic Mulch: Mulch including: Shredded Bark, Wood Chips, Pine Needles, Cocoa Bean Hulls, or other Owner approved organic mulches, shall be free of material detrimental to healthy plant growth. Organic Mulch shall be 1/8" nominal thickness, with at least fifty (50) percent having an area of not less than 1 sq. inch, and no piece having an area of more than 6 sq. inches.

Weed Control Fabric: Spun-bonded, rot-resistant polypropylene fabric, water and air permeable, and unaffected by freezing and thawing, or by deterioration from fertilizers or pesticides.

Stakes: 6-8 foot (1.8 - 2.4 m) long sections of unflanged metal, or 2" x 2" (5.1 cm x 5.1 cm) hardwood.

Flexible Support Ties: 2" (5.1 cm) or wider bands of polypropylene, or elasticized or webbed strapping.

Wrapping Material: Biodegradable geotextile (fabric) trunk wrap, or waterproofed crepe wrapping paper, secured with 1" (2.5 cm) wide masking tape.

Anti-desiccant: If required as protection for leaf surfaces, anti-desiccant shall be permeable to permit transpiration, and mixed and applied in accordance with manufacturer's specifications.

Pre-emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, with a maximum of 5.5 percent inert material

Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the composition compatible with the soil test recommendations but not to exceed the following unless otherwise approved by owner or owner's representative:

Composition: [20] percent nitrogen, [10] percent phosphorous, and [10] percent potassium, by weight.

Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

## PART 3 - EXECUTION

### 3.1 PREPARATION

Receive Owner or Architect/Engineer approval of staking layout prior to excavation. Schedule site review with Owner/Architect at least three (3) days prior to the site review.

Excavate planting areas as shown in the contract drawings.

Adequately barricade with proper warning devices any planting pit left open when planting work is not in progress, and that poses a hazard to vehicles and/or pedestrians.

Notify the Owner in writing of any soil conditions, obstructions, or concerns about water drainage deemed detrimental to healthy plant growth. These conditions or obstructions shall be detailed, along with any suggestions for correction, removal or relocation. Where soil conditions, poor drainage or other obstructions are encountered that cannot be easily remedied, the Owner will designate alternate locations, and will bear the additional costs of such relocation.

The planting pit for containerized and balled and burlapped plants shall be at least 2.5 to 3 times the diameter of the soil ball, or to a dimension otherwise specified.

The planting pit for a single shrub shall be 12" (30.5 cm) wider than the root ball.

Loosen the soil beyond the edge of the planting pit. The soil at the base of the planting pit is to remain undisturbed, the depth of which shall correspond to the distance from the bottom of the soil ball to the root flare, or slightly less.

Planting pits for bare root plants shall be only broad enough to receive the full extension of the roots when the plant is set, and only deep enough to set the uppermost roots just below existing grade.

For a shrub mass planting, the entire bed area is to be tilled to a depth of 4-6" (10.2 -15.2 cm). Excavate individual shrub pits to the proper depth.

Application of Mycorrhizal Fungi: At time directed by Architect/Engineer, broadcast dry product uniformly over prepared soil at application rate recommended by manufacturer.

### 3.2 PLANTING OF TREES AND SHRUBS

Remove plant containers by cutting or carefully inverting the container. For plants grown in plastic containers slash the edges of the root ball from top to bottom with vertical 1" cuts using a sharp blade.

Root balled plants shall have rope, string, wire baskets, burlap and other wrapping material removed from the top half of the ball after the plant has been set in the hole. Remaining wrappings, other than those made from plastic or synthetic material, may be left around the bottom half of the ball.

If deciduous species are planted in leaf, they may be sprayed with an approved anti-desiccant prior to planting when so directed by the Owner.

Trees and shrubs grown using root containment material shall have the containment bag removed prior to setting.

Set trees and shrubs straight and upright, and in the center of the planting hole and on the unexcavated base of the planting pit, with the most desirable face towards the most prominent view.

Root-balled shrubs are to be carried and set in the hole by the root ball.

Backfill pits with excavated soil. No soil in frozen or muddy condition shall be used for backfilling.

When pit is approximately two-thirds backfilled, tamp down and water to eliminate air pockets. After initial watering, add remainder of the soil to the top of pit, water without puddling, and firmly tamp without overcompacting. Form a 2-3" high saucer around the outer rim of the pit prior to mulching.

### 3.3 FINISHING

Finish-grade planting areas to required elevations after plants have fully settled.

No soil is to cover the top of the root ball. All plants shall be completely mulched over the root system with a 3" layer of specified mulching material immediately after planting. Pull back mulch no less than 3" and no more than 6" from the trunk.

If used, lay weed control fabric over grade prior to mulching as per manufacturer's recommendations. Secure to slopes with "T"-shaped pin anchors.

Thoroughly water plants immediately after planting and before mulching, primarily within and filling the saucer.

Only trees so designated shall be protected with tree wrap. Secure wrapping at a minimum of 5 locations, including the top, middle and bottom of the trunk. Cover the trunk's entire surface in a spiral manner, starting at the tree's base and extending to just below the height of the lowest main branches. Overlap material at 1/2-1". Owner will be responsible for removing the tree wrap after a recommended period.

Prune any dead or broken branches. Prune newly-planted hedges as directed by the Landscape Architect or Project Representative.

Remove all twine and rope after planting, along with any labels attached around trunks or branches.

### 3.4 STAKING

Stake only those individual plants designated on-site by Owner.

Space stakes evenly outside of, and driven clear of, the root ball. Stakes are to be driven at an angle then drawn to vertical.

Ties made of approved material shall be directly attached to the stakes. Attach ties so as to allow for 1-3" of sway in the trunk. For drooping stems, ties shall be placed at the point on the stem at which the top can then stand on its own.

Staking shall conform to any additional directions found in the drawings.

### 3.5 PLANTING OF GROUND COVERS, PERENNIALS, ANNUALS AND BULBS

Loosen soil of the planting bed to a depth of 6" by mechanical or hand tilling while soil is dry. For bulbs, the depth of loosened soil will be determined by the type of bulb planted, and specified in the contract or landscape plan

After soil is loosened, till organic compost into the soil across the planting bed to a uniform depth of 2" for compost.

Fertilizer, at amounts determined by the soil test, shall be topdressed to the soil. Liquid fertilizer may be applied to annuals if directed by Owner or Architect/Engineer.

Space as described in the landscape plan.

Unless otherwise specified, install plants no closer than 12" to the trunks of trees or shrubs within planting bed, and to within 6" of the edge of the bed.

Prior to planting, biodegradable plant containers shall be split and non-biodegradable containers removed. The root systems of all such plants shall be split or crumbled by hand.

For small quantities of bulbs, or in sections where bulbs are set within other plants, drive bulb planting holes through mulch using a bulb planter, hand trowel, or power auger. Plant bulb such that its basal plate faces downward, then cover with soil and mulch.

For larger quantities of bulbs, excavate designated areas to specified planting depth, place bulbs such that their basal plates face downward, then cover with soil and mulch. When applying mineral mulch lay weed control fabric over grade prior to mulching as per manufacturer's recommendations. Secure to slopes with "T"-shaped pin anchors.

When applying organic mulch apply pre-emergent herbicide per manufacturer's recommendations before applying mulch.

Apply approved mulch uniformly across the entire planting bed to a depth of 3" minimum, 4" maximum.

Separate mulched areas from turf areas with a 45-degree, 4- to 6-inch- deep, shovel-cut edge.

### 3.6 INSPECTION AND ACCEPTANCE

Owner and the Agency Contact responsible for maintenance following acceptance shall perform inspections with the Contractor of all plant material at one (1) week and three (3) week intervals (or other specified interval) after the original planting to note and correct any discrepancies from the contract. Plants that are alive and healthy following the three (3) week (or other time frame specified) inspection shall be accepted.

Acceptance of plant material by Owner shall reflect general conformity with the *American Standards for Nursery Stock* as to specified size, character and quality. Acceptance shall not relieve the Contractor of responsibility for full conformity to the contract documents and the guarantee period. Any defects or imperfections appearing in whole or any part of the work caused by or due to any fault or negligence on the part of the Contractor shall be corrected before the work is accepted.

Planting work may be accepted in stages when the Contractor and Owner deem that practice to be in their mutual interest. Approval must be given in writing by Owner to the Contractor verifying that work may be completed in stages. Acceptance of planting work in stages shall not waive any other provisions of the contract.

### 3.7 CLEANING

Soil, branches, binding and wrapping material, rejected plants, or other debris resulting from plant installation shall be promptly cleaned up and removed. New landscape construction in and around the planting areas are to be especially well-cleaned.

### 3.8 PRUNING

Prune in accordance with current *American National Standards (ANSI) for Tree Care Operations*. Perform all pruning work in a manner consistent with the landscape design intent. Plants overhanging and blocking pedestrian and/or vehicular paths shall be pruned as needed to allow the desired clearance.

Except in the cases of hedges, or to conform to some design intent, all pruning of ornamental trees, shrubs and ground covers should aim to retain their natural shapes. With multiple

leader plants, preserve the leader that best promote the plant's symmetry. Prune branches of deciduous stock to improve the branch structure of the plant.

Plants that flower before late spring should be pruned immediately after flowering unless otherwise directed by Owner/Architect or best practices of the industry.

Prune evergreens only to remove dead, broken or damaged branches in accordance with best practices for the plant material.

Where necessary, repairs to damaged wood shall be performed under the direction of Owner, or a certified arborist.

Prune using scissors-style cutting devices, and not anvil-style hand pruners, pole pruners or loppers.

The Contractor shall remove all trimmed branches and other debris from the site at the end of each work day.

### 3.9 MAINTENANCE

Any and all chemical applications of fertilizer are to be performed in accordance with current federal, state and local laws, through EPA-registered materials and application techniques, and performed under the supervision of a licensed certified applicator. Apply fertilizer to planted areas at the specified rate, and as per manufacturer's recommendations.

All plant materials installed under the contract shall be watered within the first 24 hours of initial planting and not less than one inch of water per week, or as otherwise required to keep plant healthy and viable, until final acceptance by Owner.

Water used shall be of sufficient quality for irrigation and free of materials harmful to plant growth.

Any use of pesticides during the contracted maintenance period, as determined by the Owner, shall utilize the minimum amount of approved pesticide needed to control pests on plant materials installed under the contract. Pesticide applications are to be performed in accordance with current federal, state and local laws, through EPA-registered materials and application techniques, and performed under the supervision of a licensed certified applicator. Apply at the specified rate, and as per manufacturer's recommendations.

END OF SECTION OF 32 92 00



## SECTION 32 92 19 - SEEDING

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Placing topsoil.
- C. Seeding, mulching and fertilizer.
- D. Maintenance.

#### 1.02 RELATED SECTIONS

- A. Section 31 23 23 - Fill and Backfill: Topsoil material.
- B. Section 31 22 00 - Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this section.
- C. 31 23 23 Fill and Backfill

#### 1.03 UNIT PRICES - MEASUREMENT AND PAYMENT

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Topsoil:
  - 1. Basis of Measurement: By the cubic yard.
  - 2. Basis of Payment: Includes topsoil, placing topsoil.
- C. Grassed Areas:
  - 1. Basis of Measurement: By the square foot.
  - 2. Basis of Payment: Includes preparation of subsoil, placing topsoil, seeding, watering and maintenance to specified time limit.

#### 1.04 DEFINITIONS

- A. Weeds: Includes but is not limited to: Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

#### 1.05 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable. Deliver seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

#### 1.07 MAINTENANCE SERVICE

- A. Furnish maintenance of seeded areas for **until accepted by Owner** unless otherwise agreed to by OWNER.
- B. Maintain seeded areas immediately after placement until grass is well established and exhibits a vigorous growing condition.

## PART 2 - PRODUCTS

### 2.01 SEED MIXTURE

- A. Temporary Seed Mixture: Refer to seeding schedule located in construction documents sheet C-1.0, General Notes and Landscape Plans.
- B. Permanent Seed Mixture: Refer to plant schedule located on the landscape plans within the construction documents.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Verify that prepared soil base is ready to receive the work of this Section.

### 3.02 PREPARATION

- A. Prepare subgrade in accordance with Section 31 22 00.
- B. Place topsoil in accordance with Section 31 22 00.
- C. Remove debris and prepare smooth soil free of dips and divots prior to seeding.
- D. Apply pre and post emergent per supplier's recommendation and in a manner that limits weed competition and promotes grass seed growth.

### 3.03 FERTILIZING

- A. Apply fertilizer in accordance with manufacturer's instructions and in accordance with soil testing recommendations.
- B. Apply after smooth raking of topsoil and prior to roller compaction.
- C. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
- D. Mix thoroughly into upper 2 inches of topsoil.
- E. Lightly water to aid the dissipation of fertilizer.

### 3.04 SEEDING

- A. Apply seed in accordance with NCDOT Standard Specifications for Roads and Structures, July 2006 or as otherwise specified by seed supplier.
- B. Mulch or tack seed or provide other means of securing seed in place and promoting seed growth.
- C. Seed applied to bare soil will not be accepted.
- D. If hydroseeded, follow supplier's recommendations for application.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Do not sow immediately following rain, when ground is too dry, or during windy periods.
- D. Immediately following seeding and compacting, apply mulch to a thickness of 1/8 inches. Maintain clear of shrubs and trees.
- E. Apply water with a fine spray immediately after each area has been mulched. Saturate to 4 inches of soil, but do not wash seed away with water application.

- F. Following germination, immediately re-seed areas without germinated seeds that are larger than 4 by 4 inches.
- G.. Finished surface of seeded area and underlying grade to be smooth without dips, trenches, or depressions. Any irregularities should be repaired immediately and the site should be monitored regularly to address problems as they occur.

### 3.05 MAINTENANCE

- A. Mow grass at regular intervals to maintain at a maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at any one mowing.
- B. Water to prevent grass and soil from drying out and to maintain healthy, viable turf grass. Maintain moisture per manufacturer's recommendations to promote growth. If no irrigation is part of contract, it is the contractor's responsibility that grass seed is watered to promote healthy, viable turf within maintenance and warranty periods.
- C. Control growth of weeds. Apply herbicides in accordance with seed supplier and herbicide manufacturer's instructions. Remedy damage resulting from improper use of herbicides.
- D. Immediately reseed areas which show bare spots.
- E. Water, fertilize, mulch or tack, and apply pre/post emergent as needed to assure healthy, viable seeded areas.

END OF SECTION 32 92 19

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## SECTION 32 92 19.16 – HYDRAULIC SEEDING

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Placing topsoil.
- C. Seeding, mulching and fertilizer.
- D. Maintenance.

#### 1.02 RELATED SECTIONS

- A. Section 31 23 23 - Fill and Backfill: Topsoil material.
- B. Section 31 22 00 - Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this section.
- C. 31 23 23 Fill and Backfill

#### 1.03 UNIT PRICES - MEASUREMENT AND PAYMENT

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Topsoil:
  - 1. Basis of Measurement: By the cubic yard.
  - 2. Basis of Payment: Includes topsoil, placing topsoil.
- C. Grassed Areas:
  - 1. Basis of Measurement: By the square foot.
  - 2. Basis of Payment: Includes preparation of subsoil, placing topsoil, seeding, watering and maintenance to specified time limit.

#### 1.04 DEFINITIONS

- A. Weeds: Includes but is not limited to: Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

#### 1.05 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.

#### 1.06 SUBMITTALS

- A. Provide product data for:
  - .1 Seed
  - .2 Mulch
  - .3 Tackifier
  - .4 Fertilizer

- B. Submit in writing to Owner seven (7) working days prior to commencing work:
  - .1 Volume capacity of hydraulic seeder.
  - .2 Amount of material to be used per tank based on volume.
  - .3 Number of tank loads required per acre to apply specified slurry mixture per acre.

#### 1.07 QUALITY ASSURANCE

- A. Test Reports: certified test reports showing compliance with specified performance characteristics and physical properties.
- B. Certificates: product certificates signed by manufacturer certifying materials comply with specified performance characteristics and criteria and physical requirements.
- C. Pre-Installation Meetings: conduct pre-installation meeting to verify grading is complete, project requirements, installation instructions and warranty requirements.
- D. Contractor Qualifications:
  - .1 Landscape Contractor: to be licensed landscape contractor in North Carolina in good standing with the licensure board.
  - .2 Provide proof of qualifications when requested by Owner.

#### 1.08 SCHEDULING

- A. Schedule hydraulic seeding to coincide with preparation of soil surface.
- B. Verify seeding timeline with Owner or Owner's Representative at least 1 month prior to performing work.

#### 1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver seed mixture in sealed containers. Seed in damaged packaging is not acceptable. Deliver seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.
- B. Deliver, store and handle materials in accordance with Section with manufacturer's written instructions.
- C. Labelled bags of fertilizer identifying mass, mix components and percentages, date of bagging, supplier's name and lot number.
- D. Inoculant containers to be tagged with expiry date.
- E. Store fertilizer indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.

- F. Replace defective or damaged materials with new.

## WARRANTY

- A. All areas hydroseeded under this contract shall have a warranty period of one (1) year from the date of Certificate of Substantial Performance shall cover any defects in materials and workmanship or damages caused by the elements of weather. All defects shall be repaired to the satisfaction of the Owner at no cost to the Owner.

### 1.12 MAINTENANCE SERVICE

- A. Furnish maintenance of seeded areas **until accepted by Owner** unless otherwise agreed to by OWNER.
- B. Maintain seeded areas immediately after placement until grass is well established and exhibits a vigorous growing condition.

## **PART 2 PRODUCTS**

### 2.01 MATERIALS

- A. Temporary Seed Mixture: Refer to seeding schedule located in construction documents sheet C-1.0, General Notes and Landscape Plans.
- B. Permanent Seed Mixture: Refer to plant schedule located on the landscape plans within the construction documents.
- a. Contractor to follow permanent seeding erosion control specifications or submit mixture composition to Owner or Owner's Representative for approval prior to order and installation.
- C. Mulch: specially manufactured for use in hydraulic seeding equipment, non-toxic, water activated, green colouring, free of germination and growth inhibiting factors with following properties:
- .1 Type I mulch:
- a. Made from wood cellulose fibre.
- b. Organic matter content: 95% plus or minus 0.5%.
- c. Value of pH: 6.0.
- d. Potential water absorption: 800-900%.
- .2 Type II mulch:
- a. Made from newsprint, raw cotton fibre and straw, processed to produce fibre lengths of 0.5 inches minimum and 1 inch maximum. Greater proportions of ingredients to be straw.
- D. Tackifier: water dilutable, liquid dispersion.
- E. Water: free of impurities that would inhibit germination and growth.
- F. Fertilizer:

1. Comply with regulatory agencies for fertilizer and herbicide composition.
2. Complete synthetic, slow release with 35% of nitrogen content in water-insoluble form.

### **PART 3**   **EXECUTION**

#### **3.01 WORKMANSHIP**

- A. Do not spray onto structures, signs, guide rails, fences, plant material, utilities and other than surfaces intended.
- B. Clean-up immediately, any material sprayed where not intended, to satisfaction of Owner.
- C. Do not perform work under adverse field conditions such as wind speeds over 10 km/h, frozen ground or ground covered with snow, ice or standing water.
- D. Protect seeded areas from trespass until plants are established.

#### **3.02 PREPARATION OF SURFACES**

- A. Do not perform work under adverse field conditions such as wind speeds over 10 km/h, frozen ground or ground covered with snow, ice or standing water.
- B. Fine grade areas to be seeded free of humps and hollows. Ensure areas are free of deleterious and refuse materials.
- C. Cultivated areas identified as requiring cultivation to depth of 1 inch.
- D. Ensure areas to be seeded are moist to depth of 6 inches before seeding.
- E. Obtain Owner approval of grade and topsoil depth before starting to seed.

#### **3.03 FERTILIZING PROGRAM**

- A. Fertilize prior to fine grading incorporating fertilizer equally distributed in accordance with an agreed program between Contractor and Owner.
- B. Fertilize during establishment and warranty periods to an agreed program between Contractor and Owner.

#### **3.04 PREPARATION OF SLURRY**

- A. Measure quantities of materials by weight or weight-calibrated volume measurement satisfactory to Owner. Supply equipment required for this work.
- B. Charge required water into seeder. Add material into hydraulic seeder under agitation. Pulverize mulch and charge slowly into seeder.
- C. After all materials are in the seeder and well mixed, charge tackifier into seeder and mix thoroughly to complete slurry.



### 3.04 SLURRY APPLICATION

- A. Hydraulic seeding equipment:
  - .1 Slurry tank.
  - .2 Agitation system for slurry to be capable of operating during charging of tank and during seeding, consisting of recirculation of slurry and or mechanical agitation method.
  - .3 Pumps capable of maintaining continuous non-fluctuating flow of solution.
  - .4 Supplied with not less than 6 spray pattern nozzles.
  - .5 Capable of seeding by 50 m hand operated hoses and appropriate nozzles.
  - .6 Tank volume to be certified by certifying authority and identified by authorities "Volume Certification Plate".
- B. Slurry mixture applied per hectare.
  - .1 Seed: Grass mixture 150 kg.
  - .2 Mulch: Type I 1250 kg.
  - .3 Tackifier: 20 kg.
  - .4 Water: Minimum 30,000 L.
  - .5 Fertilizer: 600 kg, ratio 5-20-20.
- C. Apply slurry uniformly, at optimum angle of application for adherence to surfaces and germination of seed.
  - .1 Using correct nozzle for application.
  - .2 Using hoses for surfaces difficult to reach and to control application.
- D. Blend application 12 inches into adjacent grass areas or sodded areas on site, if any, to form uniform surfaces.
- E. Re-apply where application is not uniform.
- F. Remove slurry from items and areas not designated to be sprayed.
- G. Protect seeded areas from trespass satisfactory to Owner.
- H. Remove protection devices as directed by Owner.

### 3.05 MAINTENANCE DURING ESTABLISHMENT PERIOD

- A. Perform following operations from time of seed application until acceptance by Owner.
- B. Grass Mixture:
  - .1 Repair and reseed dead or bare spots to allow establishment of seed prior to acceptance.
  - .2 Initial Mowing: Mow grass to 2 inches once grass reaches 3.5 to 4 inches height. Remove clippings which will smother grass or as otherwise directed by Owner.

- .3 Incrementally reduce mow height through maintenance period to establish permanent mowing height. Maintain no less than 1", no greater than 2". Do not scalp turf during mowing. Refer Section 3.07
- .4 Fertilize seeded areas ten (10) weeks after germination provided plants have mature true leaves in accordance with fertilizing program. Spread half of required amount of fertilizer in one direction and remainder at right angles; water in well.
- .5 Control weeds by manual, mechanical or chemical means. Utilizing acceptable integrated pest management practices.
- .6 Water seeded area to maintain optimum soil moisture level for germination and continued growth of grass. Control watering to prevent washouts.

### 3.05 ACCEPTANCE

- A. Seeded areas will be accepted by Owner provided that:
  - .1 Plants are uniformly established. Seeded areas are free of rutted, eroded, bare or dead spots.
  - .2 Areas have been mown at least twice.
  - .3 Areas have been fertilized.
- B. Areas seeded in fall will achieve final acceptance in following spring, one month after start of growing season provided acceptance conditions are fulfilled.

### 3.07 MAINTENANCE DURING WARRANTY PERIOD

- A. Perform following operations until acceptance of Certificate of Total Performance.
  - .1 Water seeded area to maintain optimum soil moisture level for continued growth. Control watering to prevent washouts.
  - .2 Repair and reseed dead or bare spots to satisfaction of Owner.
  - .3 Mow areas seeded once established; Incrementally reduce mow height through maintenance period to establish permanent mowing height. Maintain no less than 1", no greater than 2" height. Do not scalp turf. Repair any thin or scalped areas immediately. Remove clippings, dispose of clippings offsite or as directed by Owner.
  - .4 Fertilize seeded areas in accordance with fertilizing program. Spread half of required amount of fertilizer in one direction and remainder at right angles and water in well.
  - .5 Eliminate weeds by mechanical or chemical means. Repair and damaged turf.
  - .6 At the end of the warranty period repeat items 2-5.

### 3.08 CLEANING

- A. Upon completion of installation, remove surplus materials, rubbish, tools and equipment barriers.

END OF SECTION 32 92 19.16

## SECTION 32 92 23 - SODDING

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Placing topsoil.
- C. Fertilizing.
- D. Sod installation.
- E. Maintenance.

#### 1.02 RELATED SECTIONS

- A. Section 31 22 00 - Grading: Topsoil material.
- B. Section 31 22 00 - Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this section.
- C. Section 31 23 23 - Fill and Backfill: Topsoil material.

#### 1.03 UNIT PRICES - MEASUREMENT AND PAYMENT

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Topsoil:
  - 1. Basis of Measurement: By the cubic yard.
  - 2. Basis of Payment: Includes topsoil, placing topsoil.
- C. Sodded Areas:
  - 1. Basis of Measurement: By the square foot.
  - 2. Basis of Payment: Includes preparation of subsoil, placing topsoil, sodding, watering and maintenance to specified time limit.

#### 1.04 REFERENCES

- A. TPI (SPEC) - Guideline Specifications to Turfgrass Sodding; Turfgrass Producers International; 1995.

#### 1.05 DEFINITIONS

- A. Weeds: Includes but not limited to: Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

#### 1.06 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver sod on pallets. Protect exposed roots from dehydration.

- B. Do not deliver more sod than can be laid within 24 hours.

#### 1.08 MAINTENANCE SERVICE

- A. Furnish service and maintenance of sodded areas for three months from Date of Substantial Completion.
- B. Maintain sodded areas immediately after placement until grass is well established and exhibits a vigorous growing condition.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS

- A. Sod: TPI, Certified Turfgrass Sod quality; cultivated grass sod; type indicated in plant schedule on Drawings; with strong fibrous root system, free of stones, burned or bare spots; containing no more than 5 weeds per 1000 sq ft. Minimum age of 18 months, with root development that will support its own weight without tearing, when suspended vertically by holding the upper two corners.
- B. Topsoil: as specified in Section 32 91 13.
- C. Fertilizer: recommended for grass, with fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, as indicated by analysis.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Verify that prepared soil base is ready to receive the work of this section.

#### 3.02 PREPARATION

- A. Prepare subgrade in accordance with Section 31 22 00.
- B. Place topsoil in accordance with Section 31 22 00.
- C. Remove debris and prepare smooth soil free of dips and divots prior to sodding.

#### 3.03 FERTILIZING

- A. Apply fertilizer in accordance with manufacturer's instructions.
- B. Apply after smooth raking of topsoil and prior to installation of sod.
- C. Apply fertilizer no more than 48 hours before laying sod.
- D. Mix thoroughly into upper 2 inches of topsoil.
- E. Lightly water to aid the dissipation of fertilizer.

#### 3.04 LAYING SOD

- A. Moisten prepared surface immediately prior to laying sod.
- B. Lay sod immediately after delivery to site to prevent deterioration.
- C. Lay sod tight with no open joints visible, and no overlapping; stagger end joints 12 inches minimum. Do not stretch or overlap sod pieces.

- D. Lay smooth. Align with adjoining grass areas.
- E. On slopes 6 inches per foot and steeper, lay sod perpendicular to slope and secure every row with wooden pegs at maximum 2 feet on center. Drive pegs flush with soil portion of sod.
- F. On slopes less than 6 inches per foot and steeper, secure sod on the slope. All staples or other methods of securing sod shall leave a flush surface free of trip hazards.
- G. Water sodded areas immediately after installation. Saturate sod to 4 inches of soil.
- H. After sod and soil have dried, roll sodded areas to ensure good bond between sod and soil and to remove minor depressions and irregularities. Roll sodded areas with roller not exceeding 150#/ft of roller width.
- I. Finished surface of sod and underlying grade to be smooth without dips, trenches, or depressions. Any irregularities should be repaired immediately, and the site should be monitored regularly to address problems as they occur.

### 3.05 MAINTENANCE

- A. Mow grass at regular intervals to maintain at a maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at any one mowing.
- B. Water to prevent grass and soil from drying out or as otherwise required to maintain healthy, viable turf grass.
- C. Roll surface to remove irregularities.
- D. Level out any irregularities in soil/turf grade.
- E. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.
- F. Immediately replace sod to areas which show deterioration or bare spots.
- G. Water, fertilize, and apply pre/post emergent as needed to assure healthy, viable sodded areas.

END OF SECTION 32 92 23

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## SECTION 32 97 00 - LANDSCAPE MAINTENANCE AND EXTENDED WARRANTY

### PART 1 - GENERAL

#### SCOPE

These specifications, along with contract drawings apply to those items necessary for and incidental to the maintenance of the landscape planting, seeding, or sodding activities specified in the contract. The scope includes the maintenance activities of mowing, pruning, fertilizing, pest & weed management (pre and post emergents), and watering.

#### 1.01 SECTION INCLUDES

##### A. PART 1 - GENERAL

- Scope
- Related Work
- Definitions
- References
- Quality Assurance
- Job Conditions

##### B. PART 2 - PRODUCTS

- Materials

##### C. PART 3 – MAINTENANCE

- General Requirements
- Plant Maintenance
- Turf Maintenance
- Integrated Pest Management, Herbicide, and Pesticide Applications

#### 1.01 RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

- Section 32 92 19 Seeding
- Section 32 92 23 Sodding

#### 1.02 DEFINITIONS

Landscape Maintenance Provider – Insured and bonded contractor, with a minimum of 5 years of experience in landscaping including grading, seeding, sodding, planting and hardscapes. The Landscape Contractor shall be the Landscape Maintenance Provider.

#### REFERENCES

- ANSI Z60.1 American Standards for Nursery Stock
- ANSI A300 American National Standard for Tree Care Operations - Tree, Shrub and Other Woody Plant Maintenance-Standard Practices

### 1.03 QUALITY ASSURANCE

Soil Analysis: A soil test and analysis of a wide representation of soils through out the intended planting and turf areas. For each unamended soil type and each selected location, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil. The test results should also include the soil-testing laboratory's recommendations for any corrective measures needed to grow healthy, thriving specified plant material or turf on the site.

Testing methods and written recommendations shall comply with USDA's Handbook No. 60.

The soil-testing laboratory shall be given samples with information including depth and location, and number of samples taken over the entire site. If the Owner or Architect chose, the contractor may be required to have the soil-testing laboratory oversee the soil sampling. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.

Report suitability of and recommended alterations of tested soil for healthy, thriving plant & turf growth.

Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.

Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

Fertilizer shall be delivered to the site in original, sealed containers, and stored in a waterproof space. Containers shall bear the manufacturer's name, analysis, trademark and guarantee unless otherwise approved by Owner or Architect.

Collection of soil specimens shall be complete in accordance with accepted practices, and shall be subject to approval by the Owner.

### 1.04 JOB CONDITIONS

Protect all plants, lawns, and grass areas from damage at all times. Damaged plants, lawns or grass areas shall be replaced or treated as required to conform to specifications herein for fresh stock.

Work areas shall be kept clean and orderly during the installation period. Under no condition shall debris from planting activities result in a safety hazard on-site or to adjacent off-site property.



Damage to any portion of the site, including, but not limited to, lawns or grass areas incurred as a result of replacement or installation operations shall be repaired by Maintenance Provider at no cost to Owner.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

Topsoil: Naturally fertile, agricultural soil, capable of sustaining vigorous growth, of uniform composition throughout, without admixtures of subsoil, free of clay, stones larger than 1" inch diameter, roots, trash and debris of any kind, supplied by Maintenance Provider at his/her expense, and subject to approval by the Owner or Architect/Engineer.

Organic Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings. Organic Matter Content: 50 to 60 percent of dry weight.

Fertilizer: Granular, non-burning product composed of not less than fifty (50) percent organic slow-acting, guaranteed analysis professional fertilizer. Commercial fertilizer shall conform to North Carolina State Statutes, Article 56, Section 106-655, "North Carolina Commercial Fertilizer Law" and meet the standards of the North Carolina Department of Agriculture as to registration and labeling. Fertilizer shall be specified in the contract documents as to composition but is subject to revision to suit project site conditions.

Organic Mulch: Shredded Bark, free of material detrimental to healthy plant growth. Organic Mulch shall be 1/8" nominal thickness, with at least fifty (50) percent having an area of not less than 1 sq. inch, and no piece having an area of more than 6 sq. inches.

Stakes: 6-8 foot (1.8 - 2.4 m) long sections of unflanged metal, or 2" x 2" (5.1 cm x 5.1 cm) hardwood or other staking system as approved by Owner or Architect.

Flexible Support ties: 2" (5.1 cm) or wider bands of polypropylene, or elasticized or webbed strapping.

Wrapping material: Biodegradable geotextile (fabric) trunk wrap, or waterproofed crepe wrapping paper, secured with 1" (2.5 cm) wide masking tape.

Nonselective Herbicides: EPA registered and approved glyphosate based herbicide for *upland* use (broad spectrum, non-persistent) intended for vegetation removal while preparing seed beds and for maintenance during establishment period and recommended surfactants and adjuvants.

EPA registered and approved glyphosate based herbicide for *wetland* use (broad spectrum, non-persistent) intended for vegetation removal while preparing seed beds and for maintenance during establishment period and recommended surfactants and adjuvants.

Pre-emergent Herbicide effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

Post-Emergent Herbicide effective for controlling weed growth that has already germinated.

Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, with a maximum of 5.5 percent inert material

Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.

Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

## PART 3 - MAINTENANCE

### 3.01 GENERAL REQUIREMENTS

Introduction: This section establishes minimum standards and procedures for grounds maintenance services. Resource-efficient and sustainable landscape management practices have been incorporated throughout the specifications

Part of Contract: This maintenance specification is part of the contract. Compliance with the requirements herein is mandatory. In the event of question or dispute over applicability of any requirement, the requirement shall be assumed to apply, unless the Owner/Architect provides written clarification stating that it does not.

Maintenance and Guarantee Period: The start date for the maintenance period and warranty period for all areas is the date (month, day, and year) that the seeding/planting is considered substantially complete by the Owner. The maintenance period will continue for exactly one (1) year from the start date unless otherwise stated by the Owner/Architect.

Laws, Codes, and Ordinances: The Landscape Maintenance Provider shall comply with all rules, ordinances, and regulations set forth by the State, or other entity having jurisdiction, which apply to the work site, the Landscape Maintenance Provider, or Landscape Maintenance Provider's personnel.

**Safety:** The Landscape Maintenance Provider shall comply at all times with all local, state, or other legal requirements for safety, including operating all equipment in conformance with the manufacturer's operating instructions for each, and in compliance with Federal Occupational and Health Safety Administration (OSHA) standards and requirements. The safety provisions of applicable building and construction codes shall be observed. No work shall be performed in any manner or location that may endanger the health, safety, or welfare of all persons, including employees, from foreseeable injury, or damage to property.

**Protection of Existing Surfaces and Property:** The Landscape Maintenance Provider shall take proper precautions to protect existing vegetation, structures, infrastructure and utilities. Injuries to any person or damage to State property, the property of employees, customers or any property not belonging to the Landscape Maintenance Provider shall be reported immediately to the Owner. Damage or destruction as a result of the Landscape Maintenance Provider's operations shall be repaired or replaced at the Landscape Maintenance Provider's expense and to the satisfaction of the Owner.

Damage to items covered by this provision include, but are not limited to, curbs, sidewalks, lawns (including scalped areas), plantings, trees, signs, down spouts, and refuse containers. Damages may be the result of, but not limited to power equipment damage to plantings or structures, improper pruning, over or under watering of plant materials, or chemical overspray.

Replacement of damaged or destroyed plant material shall be of the same size and species or cultivar as specified/ approved for installation. Replacement shall occur within two (2) weeks of identification of damage. Substitute or alternative replacement, and scheduling of replacement shall be allowed only by the Owner's written permission.

The Landscape Maintenance Provider is not responsible for losses, repair or replacement of damaged property due to extreme weather, vandalism, theft, or the acts of others over whom they have no reasonable control.

The Landscape Maintenance Provider shall inform the Owner of such losses and provide the Owner with the cause and extent of the loss and recommendations for repair or replacement.

**Interference with Intended Use:** The Landscape Maintenance Provider shall not interfere with the use of this facility and shall conduct its operations so that there is the least possible obstruction and inconvenience to the public and owner.

The Landscape Maintenance Provider shall provide forty-eight (48) hour advance notice to the Owner whenever maintenance activities prevent normal access to a site or building for a time exceeding two (2) hours. It is the Owner's responsibility to provide notice to building occupants. The Owner will inform the Landscape Maintenance Provider of any special events or circumstances that will limit the Landscape Maintenance Provider's ability to perform maintenance activities.

**Owner/Landscape Maintenance Provider Communication:** The Landscape Maintenance Provider shall provide the Owner with a phone number where a message can be left for the Landscape Maintenance Provider twenty-four (24) hours a day. The Landscape Maintenance Provider shall respond to messages at this number within twenty-four (24) hours. The Landscape Maintenance Provider shall also provide a number where immediate contact can be made in the event of emergencies.

In the event of imminent danger of injury to the public or damage to property, the Owner will attempt to contact the Landscape Maintenance Provider using the emergency number provided. If the Landscape Maintenance Provider does not respond within two (2) hours, the Owner reserves the right to effect such repairs itself or with another Maintenance Provider.

The Landscape Maintenance Provider shall provide the Owner with names and phone numbers of maintenance supervisors and other key personnel and further advise the Owner of personnel substitutes or replacements.

The Landscape Maintenance Provider, or other key personnel, shall attend meetings and site inspections as requested by the Owner.

**Maintenance Record Keeping:** The Landscape Maintenance Provider shall maintain an itemized log of schedule and tasks performed. The log is to be submitted monthly to the Owner and complete set of records submitted with the maintenance plan.

**Extra Work:** The Landscape Maintenance Provider shall submit requests for work that requires additional payment in writing. The Landscape Maintenance Provider shall not start work until the request has been approved in writing. Failure to obtain advance approval may result in non-payment or delays in processing payment.

The Landscape Maintenance Provider may not change the regular maintenance schedule due to unscheduled or extra work unless authorized by the Owner.

**Complaint Response:** All complaints shall be abated as soon as possible after notification; but in all cases within forty-eight (48) hours or as required by the Owner.

**Contract Renegotiation:** The Owner reserves the right to renegotiate the maintenance contract due to a change in ownership of the site, concurrent construction at the site that affects maintenance tasks, or due to other changes at the site that eliminate the need for certain tasks.

**Failure to Perform:** The Owner may terminate the contract at any time at its sole discretion by delivering written notice to the Landscape Maintenance Provider. In the event the Landscape Maintenance Provider terminates the contract, such termination will require written notice to that effect to be delivered by the Landscape Maintenance Provider to the Owner not less than ninety (90) days prior to said termination.

**General Practice Guidelines:** This document is a benchmark of minimum standards for grounds maintenance. All sites governed by these specifications shall be maintained with good horticultural practices to ensure normal and healthy growth of landscape plantings, and in a resource-efficient, sustainable, and cost-effective manner.

The Landscape Maintenance Provider shall furnish all labor, equipment, materials, and transportation necessary to complete the maintenance of landscape improvements as specified herein. The Landscape Maintenance Provider shall provide services at whatever frequency is necessary to meet the specified standards.

The Landscape Maintenance Provider shall acquaint himself with the location of utilities, which may be encountered or be affected by the work, and shall be responsible for damage caused by failure to provide proper precautions or protection. Consult with the Owner and contact Digger's Hotline (North Carolina 811) to locate existing underground utilities prior to performing any work requiring subsurface excavation.

All turf shall be mowed with professional quality mulch-mowing equipment. Prior to award of contract, the Landscape Maintenance Provider shall provide the Owner with the manufacturer and model of equipment to be used.

Mowers, trimmers and other equipment shall be properly maintained to operate at "normal" operating sound levels. Equipment that is generating excessive noise or is otherwise objectionable to the Owner or building tenants shall be discontinued from use, at the Owner's request, until repairs can be affected.

The Landscape Maintenance Provider is encouraged to use non-polluting devices like rakes and brooms when feasible. The Owner prefers low-decibel, low-fossil fuel consumption, and low-emissions models of blowers, trimmers, and other power equipment. Do not use blowers around parked cars to avoid scratching vehicle paint with blowing sand and debris. Do not blow trash or debris onto the property of others.

### 3.02 PLANT MAINTENANCE (TREES, SHRUBS AND PERNNIAL PLANTS)

Inspection and Acceptance: Owner and the Agency Contact responsible for maintenance following acceptance shall perform inspections with the Maintenance Provider of all plant material at one (1) week and three (3) week intervals (or other specified interval) after the original planting to note and correct any discrepancies from the contract. Plants that are alive and healthy following the three (3) week (or other time frame specified) inspection shall be accepted.

Acceptance of plant material by Owner shall reflect general conformity with the *American Standards for Nursery Stock* as to specified size, character and quality. Acceptance shall not relieve the Maintenance Provider of responsibility for full conformity to the contract documents and the guarantee period. Any defects or imperfections appearing in whole or any part of the work caused by or due to any fault or negligence on the part of the Maintenance Provider shall be corrected before the work is accepted.

Planting work may be accepted in stages when the Maintenance Provider and Owner deem that practice to be in their mutual interest. Approval must be given in writing by Owner to the Maintenance Provider verifying that work may be completed in stages. Acceptance of planting work in stages shall not waive any other provisions of the contract.

Warranty: At the end of the first full growing season (on, or around November 1st) Maintenance Provider shall arrange to meet with the Owner or Owner's representative to coordinate initial acceptance. Owner or Owner's representative will provide the Maintenance Provider with a list of any final punch list items that need to be performed. Upon confirmation that the punchlist items were completed, a letter of acceptance will be issued.

All plants shall be warranted to be in healthy and flourishing condition after the end of one full growing season.

Maintenance Provider shall warranty all planting for an additional one full growing season after Initial Acceptance for a total warranty/maintenance period of two full growing seasons.

At any time during the warranty period, the Maintenance Provider shall remove or replace, without cost to the Owner, and within a specified planting period, all plants not in a healthy and flourishing condition as determined by the Owner or Architect/Engineer.

Replacement plants shall be subject to the same specified requirements of the contract. The warranty of replacement plants shall extend for one year. If one year warranty ends during a dormant season, the warranty shall extend at least one month into the following growing season (or as otherwise specified by the Owner/Architect). In the event that a replacement plant is not acceptable during, or at the end, of the said warranty extension period, Owner may choose between subsequent replacement or credit for that item.

Include the following remedial actions as a minimum:

- Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
- Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

A limit of one replacement of each plant will be required except for losses or replacements due to failure to comply with requirements.

Warranty /Performance Standards: at the end of the Warranty Maintenance Period and at the time of final acceptance of the following performance standards shall be met:  
100% of the woody material shall be alive and growing in a healthy condition.  
97% of the planted plugs and container-grown plants (other than woody material) shall be alive and in a healthy condition.

Cleaning: Soil, branches, binding and wrapping material, rejected plants, or other debris resulting from plant installation shall be promptly cleaned up and removed. New landscape construction in and around the planting areas are to be especially well-cleaned.

Pruning: Prune in accordance with current *American National Standards (ANSI) for Tree Care Operations*. Perform all pruning work in a manner consistent with the landscape design intent. Plants overhanging and blocking pedestrian and/or vehicular paths shall be pruned as needed to allow the desired clearance.

Except in the cases of hedges, or to conform to some design intent, all pruning of ornamental trees, shrubs and ground covers should aim to retain their natural shapes. With multiple leader plants, preserve the leader that best promote the plant's symmetry. Prune branches of deciduous stock to improve the branch structure of the plant.

Plants that flower before late spring should be pruned immediately after flowering unless otherwise directed by Owner/Architect or best practices of the industry.

Prune evergreens only to remove dead, broken or damaged branches in accordance with best practices for the plant material.

Where necessary, repairs to damaged wood shall be performed under the direction of Owner, or a certified arborist.

Prune using scissors-style cutting devices, and not anvil-style hand pruners, pole pruners or loppers.

The Maintenance Provider shall remove all trimmed branches and other debris from the site at the end of each work day.

Fertilizing: Any and all chemical applications are to be performed in accordance with current federal, state and local laws, through EPA-registered materials and application techniques, and performed under the supervision of a licensed certified applicator. Apply fertilizer to planted areas at the specified rate, and as per manufacturer's recommendations.

Excessive nutrients can be a hindrance in establishing native perennials and plugs. Do not apply fertilizer in these planting areas unless approved by the Owner/Architect.

Watering: All plant materials installed under contract shall be watered within the first 24 hours of initial planting and not less than twice weekly until final acceptance by the Owner. Additional watering may be required during the warranty period. Water used shall be of sufficient quality for irrigation and free of materials harmful to plant growth.

Pesticide: Any use of pesticides during the contracted maintenance period, as determined by the Owner, shall utilize the minimum amount of approved pesticide needed to control pests on plant materials installed under the contract. Pesticide applications are to be performed in accordance with current federal, state and local laws, through EPA-registered materials and application techniques, and performed under the supervision of a licensed certified applicator. Apply at the specified rate, and as per manufacturer's recommendations.

Native perennials and plugs: Maintain for the warranty period by watering, weeding and other operations as required to establish healthy, viable plantings. Do not let weedy volunteer species exceed 10% of the ground cover. Hand weed and/or use appropriate herbicide (by licensed applicator) at a minimum of twelve times each growing season during the maintenance period. Submit dated time sheets of required maintenance operations to Owner. Hand pulling should include removal of all above ground and below ground stems, roots and flower masses prior to development of seeds. Care should be taken to disturb as little soil as possible during the hand pulling to avoid exposure of additional weed seed in the soil layer and protect adjacent plantings.

Wildlife Control Measures: Maintenance Provider shall monitor the plantings during the warranty period to identify predation by wildlife and take all reasonable measure to protect the plant material from predation. These measures may include fencing, barriers, repellents, and frightening devices.

At the conclusion of the warranty/maintenance period, the maintenance provider shall conduct a training/review session with the Owner's maintenance staff to review existing conditions and discuss required maintenance activities for each distinct type of plant community. The following issues shall be reviewed: monitoring plant health and spread of weed species; yearly mowing and/or prescribed burning operations/ control methods for

removing weed species; herbivore protection; and enhancement /repair operations. Long-term stewardship recommendations will be provided to the Owner's staff in writing.

### 3.03 TURF MAINTENANCE

Maintenance shall consist of all facets of care for seeded or sodded turf grass areas.

Fertilization: The Maintenance Provider shall provide soil tests performed by an approved laboratory during the first year of the contract to determine turf fertility and pH requirements. Collect samples from at least three (3) locations in the turf area and combine into one (1) composite sample. Collect additional composite samples where turf is visibly non-uniform. Use a soil probe or auger to collect soil (4) inches deep. Submit the test results and recommendations to the Owner.

Fertilize turf areas with slow-release synthetic (supplies at least twenty-five to fifty percent (25-50%) slow-release nitrogen), organic, or a combination fertilizer as required to provide deep rooting and a healthy, green appearance. Determine application rates from soil test results. The Landscape Maintenance Provider shall submit a fertilizer schedule, listing proposed materials, application rates and timing prior to performing any turf fertilization.

Apply no more than one (1) pound of nitrogen per one thousand (1000) square feet of turf area at one time.

Average quality turf shall receive at least two (2) applications of fertilizer each year, one early in growing season and one no later than one month before the end of the growing season.

The use of lawn fertilizers with phosphorus is prohibited.

Weed Control: The Landscape Maintenance Provider shall apply the concepts of Integrated Pest Management to turf weed control. Pre and post emergent to be applied as needed or as approved by Owner and/or Architect. Good cultural management practices (mowing, fertilizing, and irrigation) will minimize weed problems.

Average quality turf: post-emergent herbicides may be applied during the active growing season to control broadleaf weeds when weed cover exceeds ten percent (10%) of turf or as otherwise determined necessary by Owner or Architect.

Material and method to be used shall be discussed with the Owner prior to any herbicide applications. Spot applications of low-hazard herbicides targeted to the specific weed problem shall be selected whenever possible.

Applications of all weed control products shall conform to Department of Agriculture, Trade and Consumer Protection posting requirements. Applications shall be at the minimum rate allowed on the product label and shall be applied by State certified applicators.

Pre-emergent herbicide crabgrass control may be applied to turf areas by May 1 to prevent crabgrass seed germination. Spot treat only in areas of previous year's infestation. The Landscape Maintenance Provider shall consult with the Owner to determine treatment areas, material and method of application.



**Insect and Disease Control:** The Landscape Maintenance Provider shall apply the concepts of Integrated Pest Management to turf insect and disease control. The Landscape Maintenance Provider shall monitor all turf areas for insects and diseases and use chemical and mechanical methods of control when possible. Chemical controls shall be used only to specific areas that have been identified by the Landscape Maintenance Provider, in consultation with the Owner, to pose significant risks to the health and appearance of the turf. In such cases, the most effective and least hazardous product shall be used.

**Aeration and Thatch Removal:** Maintenance tasks under this section shall be performed annually and coordinated with Owner to verify necessity and timing. Aerate with a vertically operating core aerator with hollow tines; cores shall be four (4) inches on center to a three (3) inch depth. Aerate in fall from September to October while turf is actively growing. Aeration may also occur in spring if needed. The Landscape Maintenance Provider shall consult with the Owner to determine whether or not cores can be left on lawn surfaces.

**Over-seed** after aeration if turf is thin or weed infested, or area is subject to heavy use. Overseeding shall be accomplished with a slice-seeding machine. Seed mix shall be approved by the Owner.

**Top-dress** turf with one-quarter to one-half ( $\frac{1}{4}$  to  $\frac{1}{2}$ ) inch of mature, weed-free compost after aeration and overseeding, as needed and approved by the Owner. Drag or rake after application to get compost into aeration holes and break up clumps of compost and aeration cores.

Remove thatch when its depth reaches one-half (½) inch on average. Thatch may be naturally decomposed by topdressing with one-quarter (¼) inch of topsoil. Remove thatch mechanically with a vertical mower or de-thatcher. De-thatch in September or October. Landscape Maintenance Provider shall remove and dispose of debris.

Seeding: Reseed or slit-seed bare spots or other areas of turf in need of renovation due to drought or winter kill in early spring or fall. The Landscape Maintenance Provider shall consult with the Owner to determine areas to be reseeded.

Watering: All turf installed under the contract shall be watered within the first 24 hours of initial planting and not less than twice weekly until final acceptance by Owner. However, watering must be closely monitored by contractor to insure healthy, viable growth of turf. Water used shall be of sufficient quality for irrigation and free of materials harmful to plant growth.

Water Source: If this facility is not irrigated it is the responsibility of the Landscape Maintenance Provider to provide a water source if not available or limited from the Owner.

### 3.04 INTEGRATED PEST MANAGEMENT, HERBICIDE, AND PESTICIDE APPLICATIONS

The Landscape Maintenance Provider shall adhere to the principals of Integrated Pest Management (IPM) during landscape maintenance.

General Concepts: Integrated Pest Management is an approach to weed, insect, and disease control that uses regular monitoring to determine if and when treatments are needed, and employs physical, mechanical, cultural, biological, and educational tactics to keep pest numbers low enough to prevent unacceptable damage or annoyance. Chemical treatments are made only when and where monitoring has indicated that the pest will cause unacceptable economic, medical, or aesthetic damage. Treatments are chosen and timed to be most effective and least hazardous to non-target organisms and the general environment.

Pest and Weed Monitoring: The Landscape Maintenance Provider shall visually inspect all landscape areas once weekly throughout the contract period to identify potential pest and weed problems. Pest problems include insect, disease, and weed infestations. The presence of a pest does not necessarily mean there is a problem. The Landscape Maintenance Provider shall keep written records of pests identified, areas where problems may be developing, and controls implemented. The Landscape Maintenance Provider shall educate himself regarding pest identification, pest life cycle, and best control methods including cultural, physical, and biological means.

The Landscape Maintenance Provider shall notify the Owner if a pest problem appears to be developing. The Landscape Maintenance Provider shall make recommendation of necessary corrective measures and either photo document or inspect the problem site jointly with the Owner and/or Architect. The provider shall keep monitoring records for review by the Owner and/or Architect and identify and execute approved control methods.

Pesticide Applications: Pesticides include all herbicides (both pre and post emergent), insecticides, fungicides, and various other substances used to control pests.

All pesticide applications shall be preceded by monitoring and positive pest identification. Combination products (for example, "weed and feed" or insect control plus fertilizer) shall

not be used. Regular calendar-based or preventative applications of pesticides are not allowed unless approved by the Owner.

All pesticides used shall be used in strict accordance with federal, state, county, and local regulations, and applied by a State of North Carolina certified Commercial Pesticide Applicator per the label directions. All applications must be posted for twenty-four (24) hours after application. All chemicals must have a MSDS filed with the owner. Pesticide application records shall be kept by the Landscape Maintenance Provider and copies provided to the Owner.

The Landscape Maintenance Provider is responsible for verifying that the pesticide used is appropriate for use with the respective plant material. Landscape Maintenance Provider is responsible for any damages incurred as a result of pesticide application and shall repair or replace any such damage at no cost to the Owner

END OF SECTION 32 97 00

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## SECTION 33 40 00 - STORM DRAINAGE PIPING

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Storm drainage piping, fittings, and accessories.
- B. Catch basins, Paved area drainage, Site surface drainage, and Detention basin.

#### 1.02 RELATED SECTIONS

- A. Section 31 23 00 - Excavation: Excavating of trenches.
- B. Section 31 23 23 - Fill and Backfill: Bedding and backfilling.
- C. Section 31 23 33 - Trenching for Site Utilities: Excavating, bedding, and backfilling.
- D. Section 33 49 13 - Manholes and Covers.
- E. Section 03 30 00 - Cast-in-Place Concrete: Concrete for cleanout base pad construction.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Pipe and Fittings:
  - 1. Basis of Measurement: By the linear foot.
- C. Catch Basins and Cleanouts:
  - 1. Basis of Measurement: By the unit for a nominal depth of 6 feet.

#### 1.04 REFERENCES

- A. AASHTO M 36 - Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains; American Association of State Highway and Transportation Officials; 2003.
- B. ASTM A 74 - Standard Specification for Cast Iron Soil Pipe and Fittings; 2005.
- C. ASTM C 12 - Standard Practice for Installing Vitrified Clay Pipe Lines; 2006.
- D. ASTM C 14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe; 2005a.
- E. ASTM C 14M - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe; 2005a.
- F. ASTM C 76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe; 2005b.
- G. ASTM C 76M - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe; 2005b.
- H. ASTM C 425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings; 2004.
- I. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets; 2005a.
- J. ASTM C 443M - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets; 2005a.
- K. ASTM C 564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings; 2003a.
- L. ASTM C 700 - Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard

Strength, and Perforated; 2005.

- M. ASTM D 1785 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2005.
- N. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications; 2005.
- O. ASTM D 2729 - Standard Specification for Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings; 2003.
- P. ASTM D 2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings; 2005.
- Q. ASTM D 3034 - Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings; 2004a.

#### 1.05 DEFINITIONS

- A. Bedding: Fill placed under, beside and directly over pipe, prior to subsequent backfill operations.

#### 1.06 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.
- B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

#### 1.07 REGULATORY REQUIREMENTS

- A. Conform to applicable code for materials and installation of the Work of this section.

#### 1.08 PROJECT CONDITIONS – NOT USED

### PART 2 - PRODUCTS

#### 2.01 SEWER PIPE MATERIALS

- A. Concrete Pipe: Reinforced, AASHTO M170, Class III with Wall type A; mesh reinforcement; bell and spigot end joints.
- B. Reinforced Concrete Pipe Joint Device: ASTM C 443 (ASTM C 443M) rubber compression gasket joint.
- C. High Density Polyethylene Pipe: N-12 WT (Watertight) by Advanced Drainage Systems, Inc. All installation shall conform to the plans and the manufacturer's recommendations.

#### 2.02 CATCH BASIN, CLEANOUT, AND AREA DRAIN COMPONENTS

- A. Concrete: Unless otherwise specified, concrete and reinforced concrete shall conform to ASTM C-94 and have a minimum 28-day compressive strength of 3,000 psi. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 3 to 6 percent when maximum size of coarse aggregates exceeds 1-1/2 inches. Air content shall be determined in accordance with ASTM C 231. The concrete covering over steel reinforcing shall be not less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches between steel and ground. Expansion-joint filler material shall conform to ASTM D 1725, D 1752, or AASHTO M 33 or

shall be resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

- B. Mortar: Mortar for drainage structures, and brick or block construction shall conform to ASTM C 270, Type S. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar but in no case shall exceed 7 gallons of water per sack of cement. Water shall be clean and free of harmful acids, alkalies, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water.
- C. Precast Concrete Segmental Blocks: Shall conform to ASTM C 139, not more than 8 inches thick, not less than 8 inches long and of such shape that joints can be sealed effectively and bonded with cement mortar.
- D. Brick: Shall conform to ASTM C 62, Grade SW; ASTM C 55, Grade S-I or S-II; or ASTM C 32, Grade MS. Mortar for jointing and plastering shall consist of one part Portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 3/4 inch of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.
- E. Reinforcing Steel: Steel reinforcement shall be protected at all times from damage and when placed in the work shall be free from dirt, dust, loose mill scale, loose rust, paint, oil, or other foreign materials. Deformed steel bar reinforcement shall conform to the requirements of ASTM A 615 for Grade 60. Tolerances for bending and cutting during fabrication shall be in accordance with the "Manual of Standard Practice" published by the Concrete Reinforcing Steel Institute. Bars shall be bent cold to the details shown on the plans. Cold drawn steel wire to be used as spirals or in fabricated form for the reinforcement of concrete shall meet the requirements of ASTM A 82. Welded wire fabric shall conform to ASTM A185.
- F. Iron Casting: Castings shall be boldly filleted at angles, and the rises shall be sharp and perfect. No sharp, unfiled angles or corners will be permitted. They shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects affecting their strength and value for the service intended. All castings shall be sand blasted or otherwise effectively cleaned of scale and sand so as to present a smooth, clean, and uniform surface.
- G. Steps: Steps for minor drainage structures shall be polypropylene encapsulated steel meeting requirement of ASTM C-478.
  - 1. Steps differing dimension, configuration, or materials from those shown on the plans may also be used provided the Contractor has furnished the Owner's Representative with details of the proposed steps and has received written approval from the Owner's Representative for the use of such steps.
- H. Stone Bedding for Drainage Structures: Stone bedding for drainage structures shall be NCDOT standard size No. 57.

## 2.03 BEDDING AND COVER MATERIALS

- A. Bedding: As specified in Section 31 23 33.
- B. Cover: As specified in Section 31 23 33.

### PART 3 - EXECUTION

#### 3.01 TRENCHING

- A. See Section 31 23 33 for additional requirements.
- B. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

#### 3.02 INSTALLATION – PIPE

- A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout drawings.
- B. Install pipe, fittings, and accessories in accordance with manufacturer's instructions. Seal watertight.
- C. Lay pipe to slope gradients noted on layout drawings; with maximum variation from true slope of 10% from structure to structure.

#### 3.03 INSTALLATION - CATCH BASINS AND CLEANOUTS

- A. Form bottom of excavation clean and smooth to correct elevation.
- B. Form and place cast-in-place concrete base pad, with provision for sanitary sewer pipe end sections.
- C. Establish elevations and pipe inverts for inlets and outlets as indicated.
- D. Mount lid and frame level in grout, secured to top cone section to elevation indicated.

#### 3.04 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 40 00.

#### 3.05 PROTECTION

- A. Protect pipe and bedding cover from damage or displacement until backfilling operation is in progress.

END OF SECTION 33 40 00



## SECTION 33 46 00 - SUBDRAINAGE

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Building Perimeter, Retaining Wall, and Under-Slab Drainage Systems.
- B. Filter aggregate and fabric and bedding.

#### 1.02 RELATED SECTIONS

- A. Section 31 23 00 - Excavation: Excavating for subdrainage system piping and surrounding filter aggregate.
- B. Section 31 023 23 - Fill and Backfill: Backfilling over filter aggregate, up to subgrade elevation.
- C. Section 31 23 33 - Trenching for Site Utilities: Excavating and backfilling for site subdrainage systems.

#### 1.03 UNIT PRICES

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.

#### 1.04 REFERENCES

- A. ASTM C 4 - Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile; 2004.
- B. ASTM C 412 - Standard Specification for Concrete Drain Tile; 2005a.
- C. ASTM C 412M - Standard Specification for Concrete Drain Tile; 2005a.
- D. ASTM D 2729 - Standard Specification for Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings; 2003.

#### 1.05 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.

#### 1.06 REGULATORY REQUIREMENTS

- A. Conform to applicable code for materials and installation of the work of this section.

### PART 2 - PRODUCTS

#### 2.01 PIPE MATERIALS

- A. Polyvinyl Chloride Pipe: ASTM D 2729; plain end, 4 inch inside diameter; with required fittings.
- B. Use perforated pipe at subdrainage system; unperforated through sleeved walls.

#### 2.02 AGGREGATE AND BEDDING

- A. Filter Aggregate and Bedding Material: Granular fill as specified in Section 31 23 23.
- B. Filter Sand and Bedding Material: Sand as specified in Section 31 23 23.

## 2.03 ACCESSORIES

- A. Pipe Couplings: Solid plastic.
- B. Filter Fabric: Water pervious type, black polyolefin. Provide a type I engineering fabric in accordance with NCDOT standard specifications for roads and structures, Section 1056, and dated July 2006.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout Drawings.

### 3.02 PREPARATION

- A. Hand trim excavations to required elevations.
- B. Remove large stones or other hard matter which could damage drainage piping or impede consistent backfilling or compaction.

### 3.03 INSTALLATION

- A. Install and join pipe and pipe fittings in accordance with pipe manufacturer's instructions.
- B. Place drainage pipe on clean cut subsoil.
- C. Lay pipe to slope gradients noted on Drawings; with maximum variation from true slope of 1/8 inch in 10 feet.
- D. Loosely butt pipe ends. Place joint cover strip 12 inches wide, around pipe diameter centered over joint.
- E. Place pipe with perforations facing down. Mechanically join pipe ends.
- F. Install pipe couplings.
- G. Install filter aggregate at sides, over joint covers and top of pipe. Provide top cover compacted thickness of 12 inches.
- H. Place filter fabric over levelled top surface of aggregate cover prior to subsequent backfilling operations.
- I. Place aggregate in maximum 4-inch lifts, consolidating each lift.
- J. Refer to Section 31 23 23 for compaction requirements. Do not displace or damage pipe when compacting.
- K. Connect to storm sewer system with unperforated pipe, through installed sleeves.

### 3.04 FIELD QUALITY CONTROL

- A. Section 01 40 00 - Quality Requirements: Field inspection and testing.
- B. Request inspection prior to and immediately after placing aggregate cover over pipe.

### 3.05 PROTECTION

- A. Protect pipe and aggregate cover from damage or displacement until backfilling operation begins.

END OF SECTION 33 46 00

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## SECTION 33 49 13 - MANHOLES AND COVERS

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Modular precast concrete manhole sections with tongue-and-groove joints with masonry transition to lid frame, covers, anchorage, and accessories.
- B. Masonry manhole sections with masonry transition to lid frame, covers, anchorage, and accessories.

#### 1.02 RELATED SECTIONS

- A. Section 03 30 00 - Cast-in-Place Concrete.
- B. Section 04 20 00 - Unit Masonry Assemblies: Masonry units and mortar and grout.

#### 1.03 UNIT PRICES - MEASUREMENT AND PAYMENT

- A. See Section 01 22 00 - Unit Prices, for additional unit price requirements.
- B. Manhole: By the unit. Includes excavating, concrete base pad, concrete manhole sections, FRP manhole sections, brick masonry manhole construction, brick masonry transition to cover frame, cover frame and cover, to indicated depth, forming and sealing pipe inlets and outlets.

#### 1.04 REFERENCES

- A. ACI 530.1/ASCE 6/TMS 602 - Specification For Masonry Structures; American Concrete Institute International; 2005.
- B. ASTM A 48/A 48M - Standard Specification for Gray Iron Castings; 2003.
- C. ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2002.
- D. ASTM C 55 - Standard Specification for Concrete Brick; 2003.
- E. ASTM C 62 - Standard Specification for Building Brick (Solid Masonry Units Made From Clay or Shale); 2005.
- F. ASTM C 478 - Standard Specification for Precast Reinforced Concrete Manhole Sections; 2006a.
- G. ASTM C 478M - Standard Specification for Precast Reinforced Concrete Manhole Sections; 2006a.
- H. ASTM C 923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals; 2002.
- I. ASTM C 923M - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals; 2002.
- J. ASTM D 3753 - Standard Specification for Glass-Fiber-Reinforced Polyester Manholes and Wetwells; 2005.
- K. IMIAWC (CW) - Recommended Practices & Guide Specifications for Cold Weather Masonry Construction; International Masonry Industry All-Weather Council; 1993.

#### 1.05 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures, for submittal procedures.
- B. Shop Drawings: Indicate manhole locations, elevations, piping sizes and elevations of

penetrations.

## 1.06 ENVIRONMENTAL REQUIREMENTS

- A. Cold and Hot Weather Requirements: Comply with requirements of ACI 530.1/ASCE 6/TMS 602 or applicable building code, whichever is more stringent.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

- A. Manhole Sections: Reinforced precast concrete in accordance with ASTM C 478 (ASTM C 478M), with resilient connectors complying with ASTM C 923 (ASTM C 923M).
- B. Concrete: As specified in Section 03 30 00.
- C. Concrete Brick Units: As specified in Section 04 20 00.
- D. Mortar and Grout: As specified in Section 04 20 00, Type S.
- E. Reinforcement: Formed steel wire, galvanized finish, wire diameter as indicated on drawings.

### 2.02 CONFIGURATION

- A. Shaft Construction: Concentric with concentric cone top section; lipped male/female dry joints; sleeved to receive pipe sections.
- B. Shape: Cylindrical.
- C. Clear Inside Dimensions: As indicated.
- D. Design Depth: As indicated.
- E. Clear Lid Opening: As indicated.
- F. Pipe Entry: Provide openings as indicated.
- G. Steps: As indicated.
- H. Steps: As required by code.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Verify items provided by other sections of Work are properly sized and located.
- B. Verify that built-in items are in proper location, and ready for roughing into Work.
- C. Verify excavation for manholes is correct.

### 3.02 MANHOLES

- A. Place concrete base pad, trowel top surface level.
- B. Place manhole sections plumb and level, trim to correct elevations, anchor to base pad.
- C. Form and place manhole cylinder plumb and level, to correct dimensions and elevations. As work progresses, build in fabricated metal items.
- D. Cut and fit for pipe.
- E. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as required.
- F. Coordinate with other sections of work to provide correct size, shape, and location.

### 3.03 MASONRY WORK

- A. Maintain masonry courses to uniform dimension. Form vertical and horizontal joints of uniform thickness.
- B. Lay masonry units in running bond. Course one unit and one mortar joint to equal 8 inches.
- C. Form concave mortar joints.
- D. Lay masonry units in full bed of mortar, with full head joints, uniformly jointed with other work.
- E. Install joint reinforcement 16 inches on center.
- F. Place joint reinforcement in first and second horizontal joints above base pad and below lid frame opening.

END OF SECTION 33 49 13

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